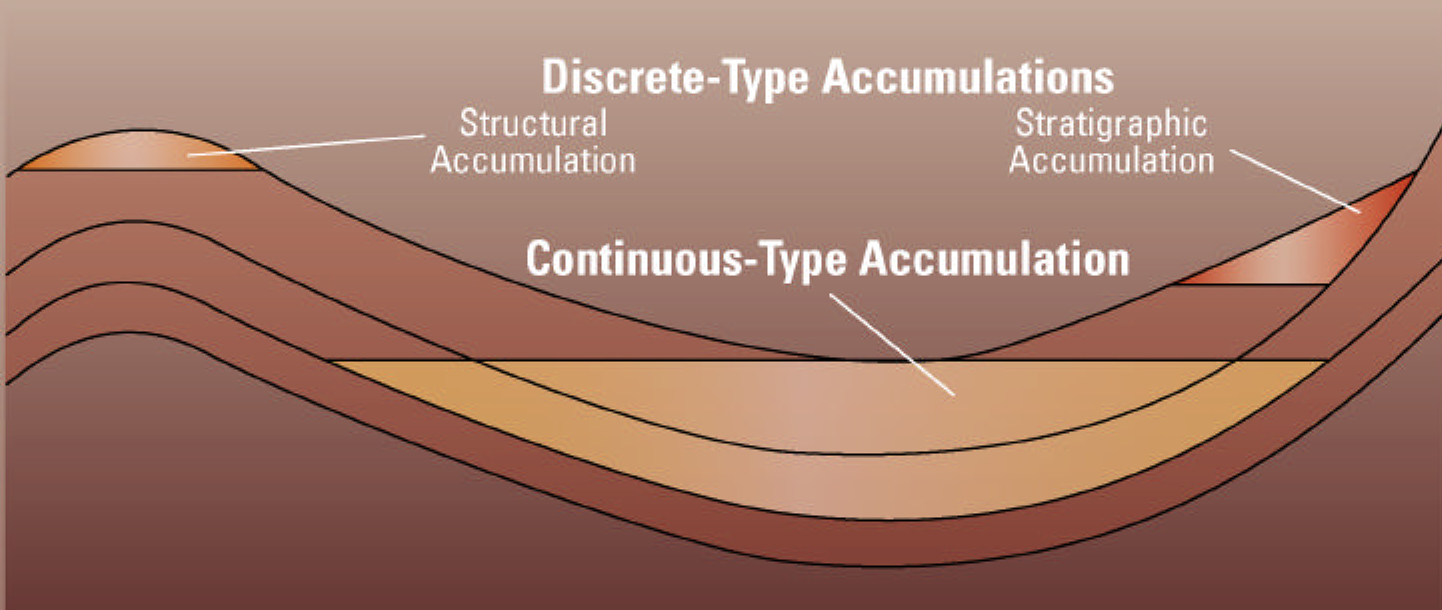
Potential for a Basin-Centered Gas Accumulation in the Raton Basin, Colorado and New Mexico

Geologic Studies of Basin-Centered Gas Systems

U.S. Geological Survey Bulletin 2184-B



U.S. Department of the Interior
U.S. Geological Survey

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By Ronald C. Johnson *and* Thomas M. Finn

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Edited by Vito F. Nuccio *and* Thaddeus S. Dyman

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This work funded by the U.S. Department of Energy, National Energy Technology Laboratory, Morgantown, W. Va., under contracts DE-AT26-98FT40031 and DE-AT26-98FT40032, and by the U.S. Geological Survey Central Region Energy Resources Team

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Posted online June 2001, version 1.0

This publication is only available online at:
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Contents

Figures

Table

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By Ronald C. Johnson[1] *and* Thomas M. Finn[1]

Abstract

The Raton Basin appears to contain a significant continuous or basin-centered gas accumulation in sandstones of the Upper Cretaceous Trinidad Sandstone and Vermejo Formation and Upper Cretaceous and Paleocene Raton Formation. The accumulation is underpressured and occurs at comparatively shallow (<3,500 ft) depths. The sandstones are interbedded with coal beds that are currently being developed for coal-bed methane, and the coals are the likely source for gas found in the sandstones. Based on analogs with other Rocky Mountain basins, relatively water-free production should occur where levels of thermal maturity in the coals exceed a vitrinite reflectance value of 1.1 percent. This level of thermal maturity occurs over much of the central part of the Raton Basin. Because of the shallow depths, some of the accumulation has probably been degraded by surface water invasion.

Introduction

The Raton Basin covers an area of about 4,000 mi^2 in southeastern Colorado and northeastern New Mexico. The basin is bounded on the west by the Sangre de Cristo Mountains, on the north by the Wet Mountains, on the southeast by the Sierra Grande arch, on the east by the Las Animas arch, and on the northeast by the Apishapa arch (fig. 1). The basin is highly asymmetrical, with the deep basin axis just east of the Sangre de Cristos. The east flank of the basin is gently tilted toward the west at from 1° to 5°, whereas steep dips and thrust faults occur along the west flank adjacent to the Sangre de Cristo Mountains. The Raton Basin is in the southeastern part of the area that was affected by the Laramide orogeny (Late Cretaceous through Eocene) in the central Rocky Mountain region. The Basin contains a thick stratigraphic section of Devonian through Plio-Pleistocene-age rocks (fig. 2).

Evidence for a basin-centered or continuous gas accumulation of some sort in the Raton Basin has been presented by many authors (Dolly and Meissner, 1977; Broadhead, 1982, 1991; Rose and others, 1986; and Woodward, 1987). The reservoir units considered by these authors most likely to contain a basin-centered gas accumulation include the Upper Cretaceous Trinidad Sandstone and Vermejo Formation, Upper Cretaceous and Paleocene Raton Formation, and the Paleocene Poison Canyon Formation (fig. 3). In addition, minor amounts of hydrocarbons have been produced on structures at shallow depths (< 3,000 ft) from fractured reservoirs in the Cretaceous Niobrara, Carlile, and Greenhorn Formations, and the Cretaceous Pierre Shale in the Raton Basin since 1892. Production from these units in the Denver Basin to the north is considered unconventional because of low pressures and low matrix permeabilities (see Denver Basin discussion in Gautier and others, 1995). It is possible that unconventional or basin-centered accumulations could occur in these fractured Cretaceous units at greater depths in the Raton Basin. This possibility has not been addressed by previous workers and is beyond the scope of this paper. The purpose of this report is to summarize the evidence for a basin-centered gas accumulation in the Trinidad Sandstone, Vermejo Formation, and Raton Formation presented by previous authors and to reexamine this evidence in light of new understandings about how basin-centered accumulations are created and destroyed.

The marginal-marine Trinidad Sandstone conformably overlies the Pierre Shale throughout the basin and was deposited along an eastward-prograding shoreline during the final retreat of the Cretaceous Seaway from northern New Mexico and southern Colorado. The Trinidad Sandstone was deposited in shallow marine, shoreface, and deltaic environments (Pillmore and Maberry, 1976; Billingsley, 1977). It varies from 0 to more than 300 ft thick (Rose and others, 1986, fig. 7) and is truncated by the Poison Canyon Formation in the northernmost part of the basin.

The Upper Cretaceous Vermejo Formation conformably overlies the Trinidad Sandstone. The Vermejo Formation varies from 0 to 380 ft thick and is also truncated by the Poison Canyon Formation in the northernmost part of the basin. The

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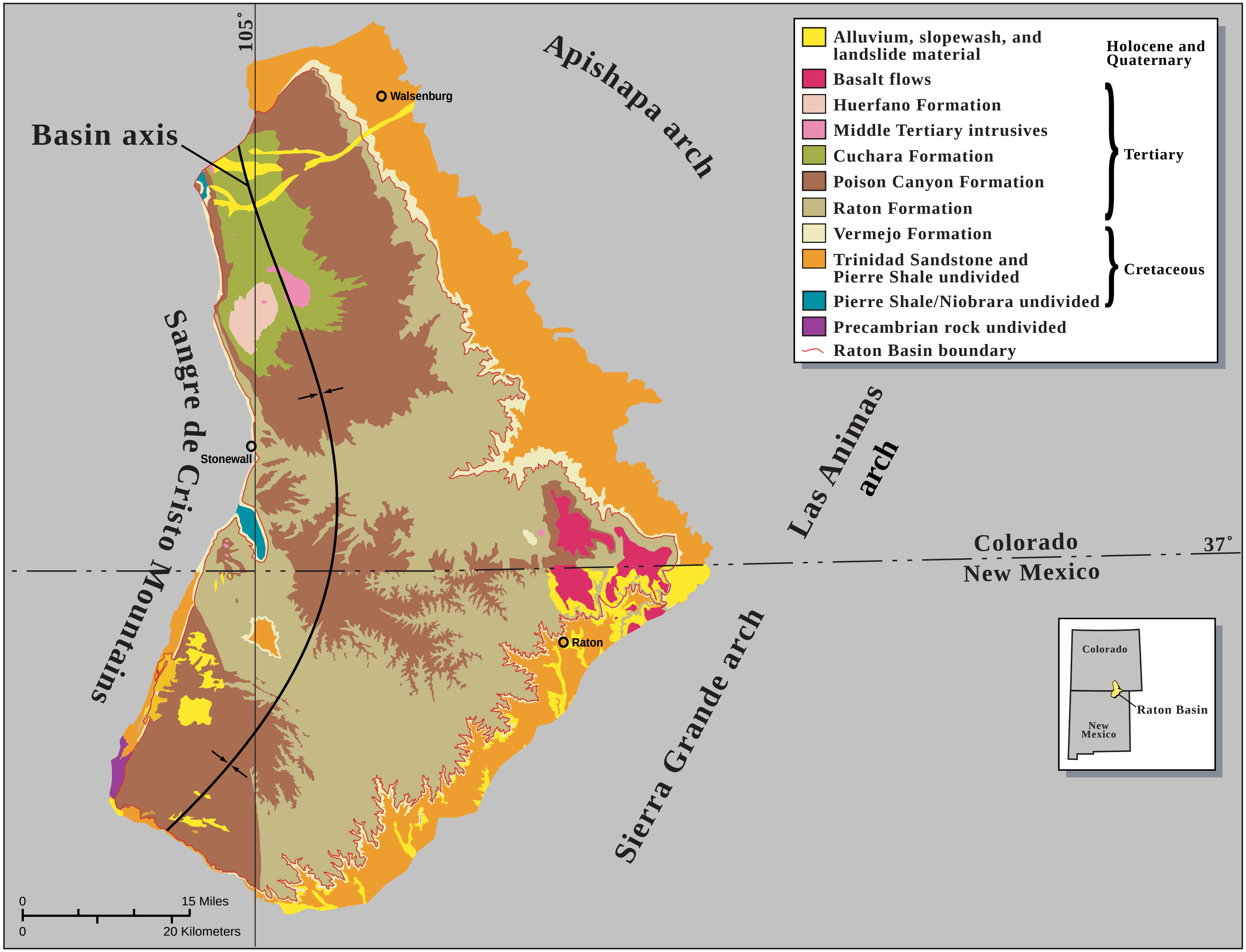

Figure 1. Generalized geologic map of the Raton Basin, Colorado and New Mexico. From Flores and Bader (1999).

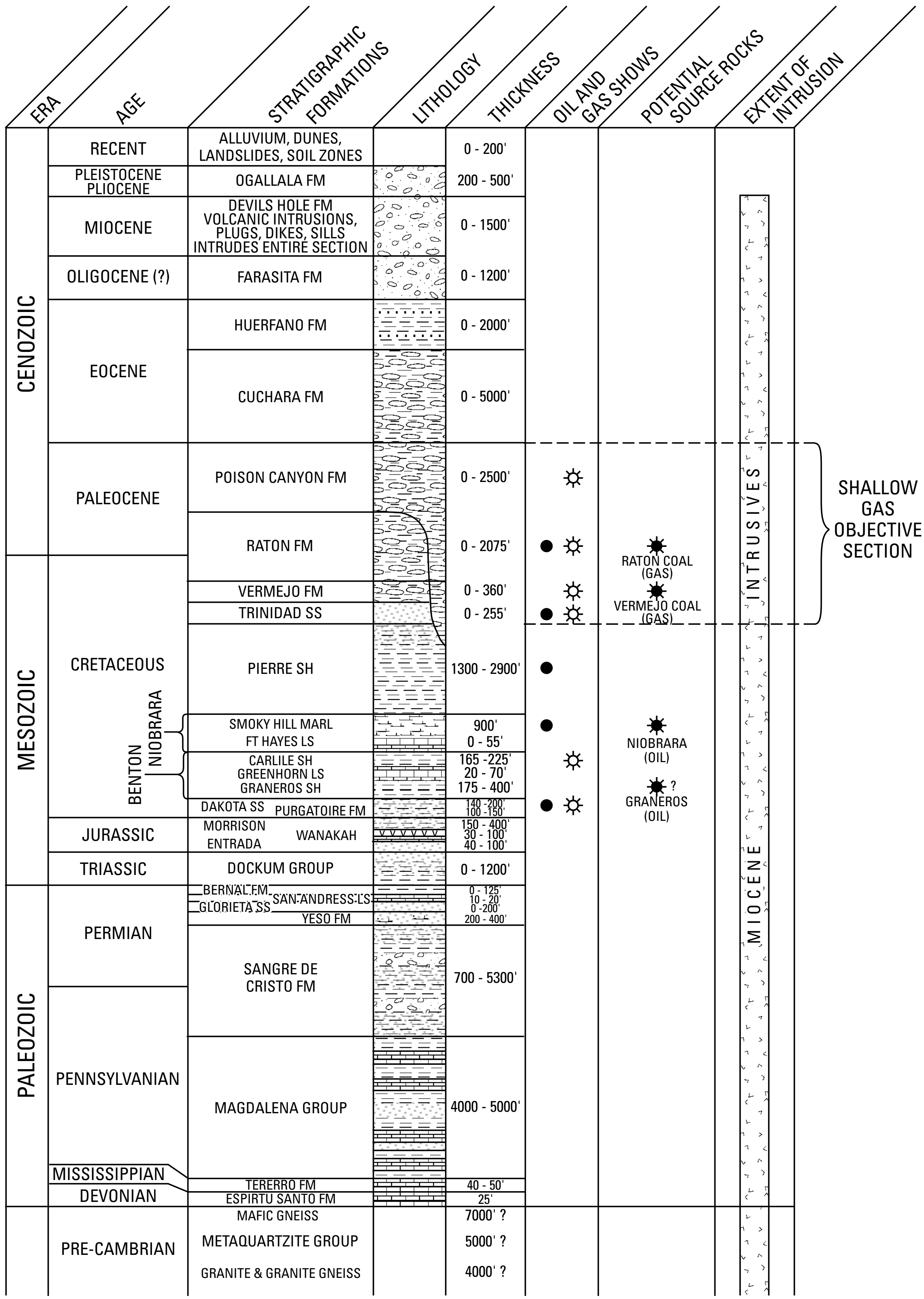

Figure 2. Generalized stratigraphic column for the Colorado portion of the Raton Basin. From Dolly and Meissner (1977).

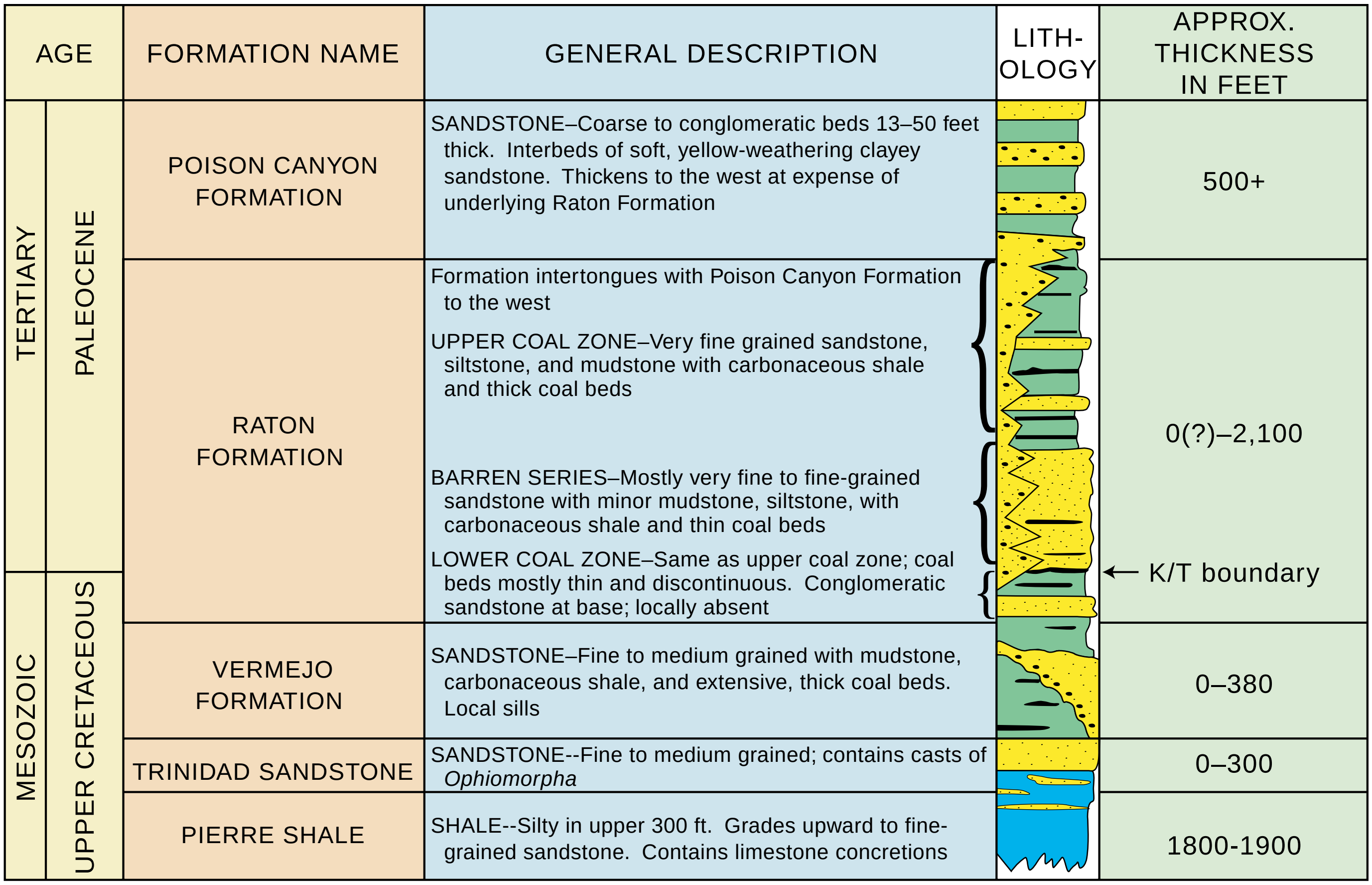

Figure 3. Generalized stratigraphic column for Cretaceous and Tertiary rocks in the Raton Basin. From Flores and Bader (1999), modified from Pillmore (1969), Pillmore and Flores (1987), and Flores (1987).

Vermejo was deposited in fluvial channel, overbank-levee, crevasse splay, flood-plain lake, low-lying and raised mire environments (Strum, 1985; Flores, 1987; Flores and Pillmore, 1987). Total coal in the Vermejo Formation ranges to more than 30 ft (Tyler and others, 1995).

The Upper Cretaceous through Paleocene Raton Formation unconformably overlies the Vermejo Formation throughout much of the basin and ranges from 0 to 2,100 ft thick. It is divided into a basal conglomeratic interval, a lower coal-rich interval, a sandstone-rich interval, and an upper coal-rich interval (fig. 4). The Cretaceous-Tertiary boundary is conformable in the Raton Basin and occurs near the top of the lower coal-rich interval in the Raton Formation (Tschudy and others, 1984; Pillmore and Flores, 1984). The basal conglomerate unit is as much as 50 ft thick and consists of interbedded pebble conglomerate and quartzose sandstone (Pillmore and Flores, 1987). The lower coal-rich zone varies from 100 to 250 ft thick, and the upper coal-rich zone varies from about 600 to 1,100 ft thick. Both are composed of interbedded sandstone, siltstone, mudstone, carbonaceous shale, and coal. The coaly intervals include lenticular channel sandstones and thin, comparatively persistent, crevasse-splay sandstones. Total net thickness of coal in the Raton Formation ranges from less than 20 ft to more than 140 ft (Tyler and others, 1995). The sand-dominated interval separates the two coal-rich zones and varies from 180 to 600 ft thick. Sandstones are coarsest in the sand-dominated interval. Estimates of total coal in both the Vermejo and Raton Formations vary from 1.5 to 4.8 billion short tons (Read and others, 1950; Wanek, 1963); however, more recently, Amuedo and Bryson (1977) estimated 5 billion short tons in the Vermejo Formation alone.

The Poison Canyon Formation varies from 0 to about 2,500 ft thick and conformably overlies and intertongues with the Raton Formation (Johnson and Wood, 1956; Flores, 1987). The formation consists of interbedded coarse-grained conglomeratic sandstone, mudstone, and siltstone (Hills, 1888; Johnson and others, 1966) and becomes finer grained toward the east in the basin. The Poison Canyon contains little coal or carbonaceous shale.

The Raton Basin was extensively intruded by dikes, sills, laccoliths, and stocks in middle to late Tertiary time. A major intrusive center of Oligocene and Miocene age (26 to 22 Ma),

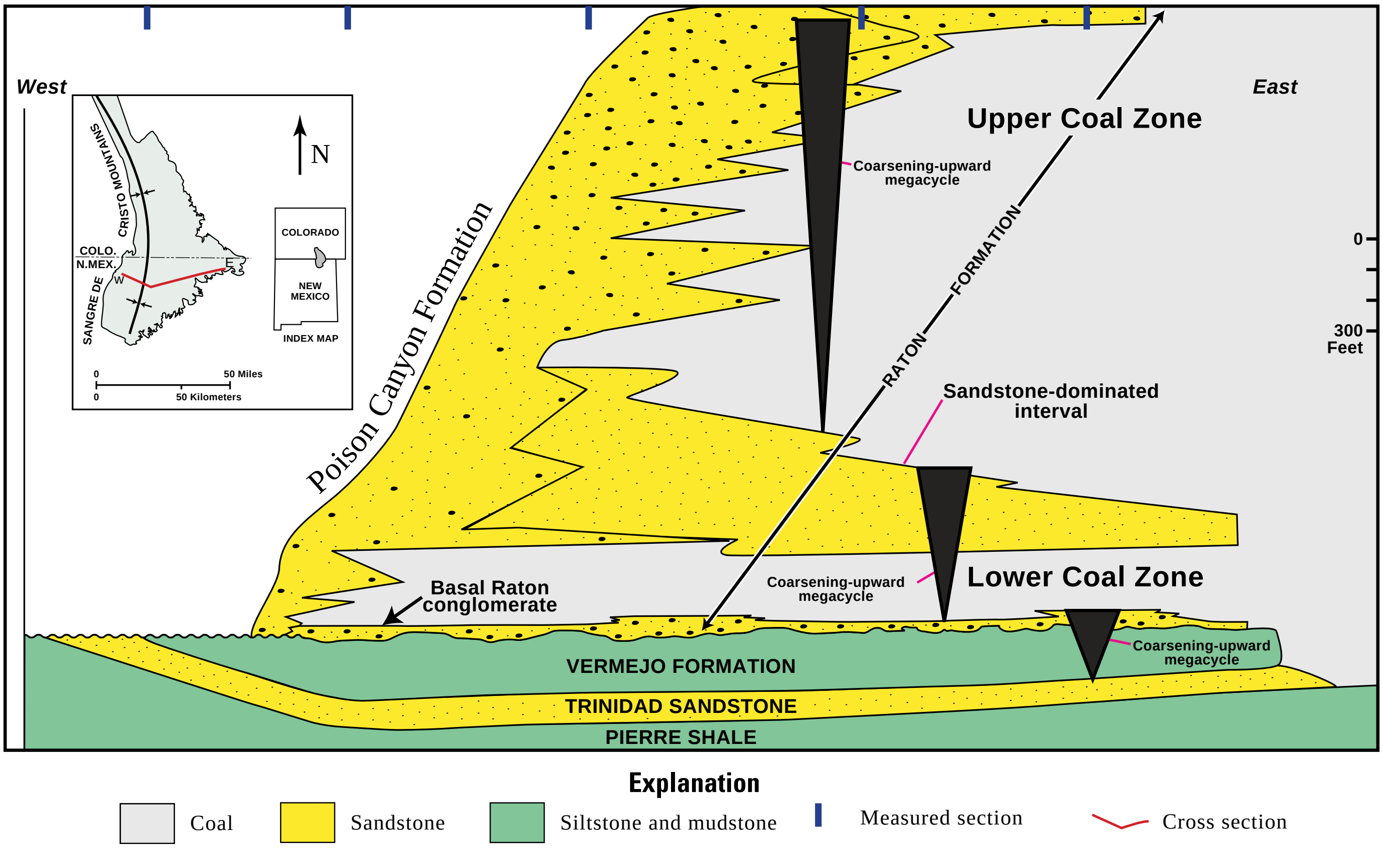

Figure 4. East-west stratigraphic cross section across the southern part of the Raton Basin showing vertical and lateral variations in Upper Cretaceous and Paleocene rocks. From Flores (1987), Flores and Bader (1999).

thought to represent the roots of breached volcanoes (Steven, 1975), occurs in the northern part of the basin (fig. 1). Two of these breached intrusions form East and West Spanish Peaks which tower over the basin at elevations of 12,683 ft and 13,724 ft, respectively. Dikes and sills related to this intrusive center occur throughout the northern part of the basin. Sills related to this intrusive center have intruded coal beds and destroyed tremendous quantities of coal in this area (Carter, 1956).

Thermal Maturity and Coal Rank in the Raton Basin

Thermal maturity at the base of the Vermejo Formation varies from a vitrinite reflectance of 0.57 percent around the margins of the northern part of the basin to 1.58 percent along the Purgatoire River in the central part of the basin (fig. 5). Coal ranks of anthracite or greater occur locally near intrusions (Jurich and Adams, 1984). The unusually high coal ranks along the Purgatoire River are unusual in that they do not occur near the major intrusions found farther to the north in the basin. Wells drilled near the river have, however, encountered some sills (ARI, Inc., 1991) that may have played a role in elevating coal ranks. Merry and Larsen (1982) suggested that the high coal ranks may be due to a combination of deep burial during the Pliocene and proximity to intrusions. Tyler and others (1991) suggested that hot waters ascending to an ancestral Purgatoire River may account for the high values near the river.

Coal-Bed Methane in the Raton Basin

It has long been known that coals in the Raton Basin contain large amounts of methane. Nearly all coal mines in the basin encountered some gas. Jurich and Adams (1984) reported that 2 million cubic feet of methane per day (MMCFD) was being ventilated from just three mines in the

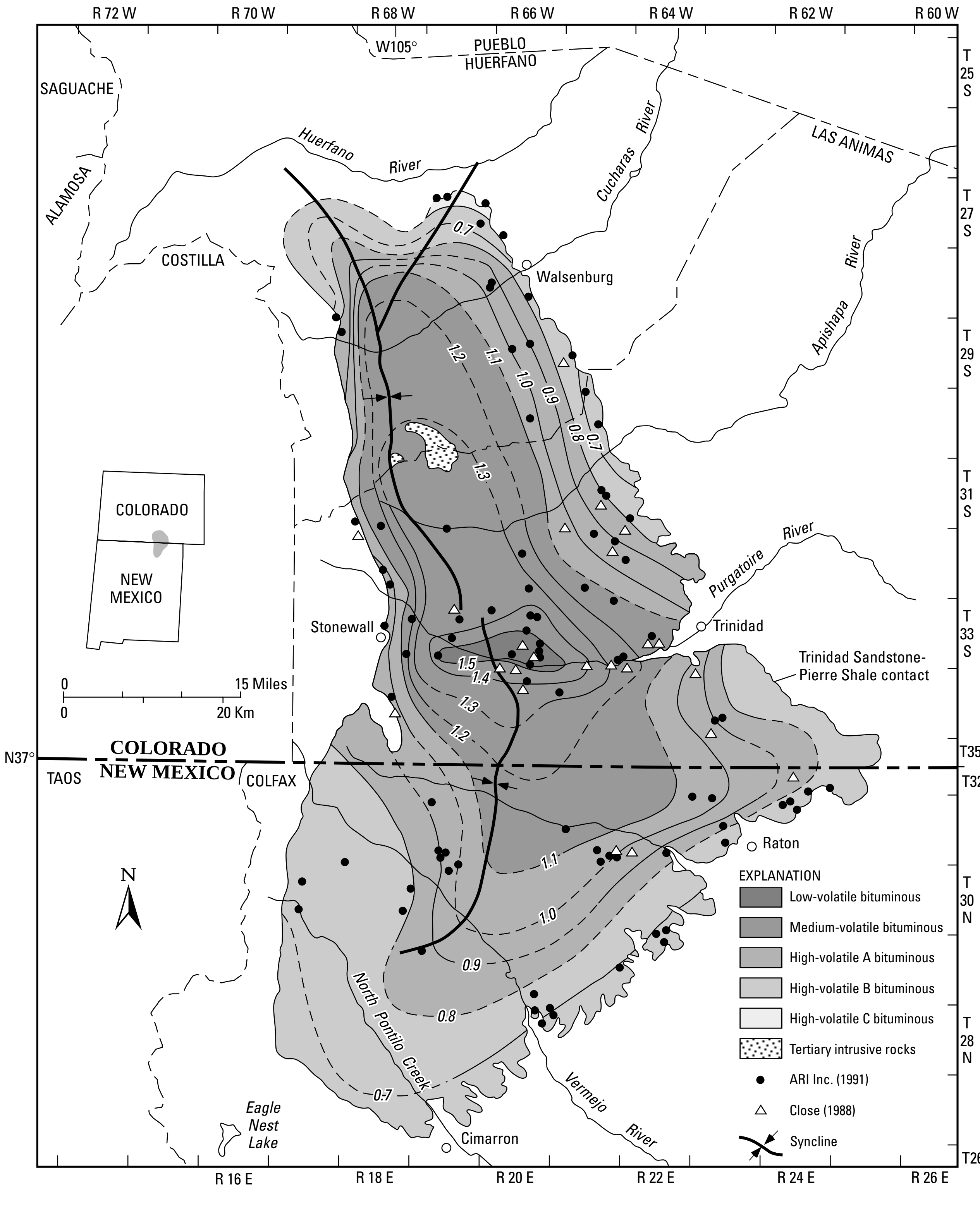

Figure 5. Coal rank map at the base of the Vermejo Formation, Raton Basin. Variations in vitrinite reflectance (percent R_o) are also shown. Adapted from Tyler and others (1995).

west-central part of the basin. Reported gas contents for coal in the Vermejo Formation vary from 115 to 492 ft3/short ton (3.6–15.5 cm3/g), whereas coals in the Raton Formation contain from 23 to 193 ft3/short ton (0.72–6.07 cm3/g) (Tyler and others, 1995). In 1998, there were about 85 coal-bed methane wells in the Raton Basin producing about 17.5 MMCFD (Johnson and Flores, 1998). By February 2000, the number of wells had increased to 459. Wells are completed mainly in the Vermejo Formation. Production thus far is concentrated in a 25- by 15-mile northeast-trending area near the Purgatoire River, west of Trinidad, Colo., in an area where coal ranks are unusually high (fig. 6). Coal-bed methane exploration began in the Raton Basin by Amoco in 1980 at their Cottontail Pass unit (fig. 6). The best wells in Amoco's unit yielded more than 590 thousand cubic feet of gas per day (MCFD). Maximum depth for coal-bed methane wells in the basin is about 2,400 ft in the northwest part of Amoco's Cottontail Pass unit.

Geology of Basin-Centered Gas Accumulations

Extensive basin-centered or continuous gas accumulations have been identified in many Rocky Mountain basins that formed during the Laramide orogeny (Late Cretaceous through Eocene). Reservoirs within basin-centered gas accumulations typically have low permeabilities (in situ permeability to gas of 0.1 millidarcy or less) and are commonly referred to as tight gas reservoirs (Spencer, 1989). These accumulations differ from conventional gas accumulations in that they (1) cut across stratigraphic units, (2) commonly occur structurally down dip from more permeable water-filled reservoirs, (3) have no obvious structural and stratigraphic trapping mechanism, and (4) are almost always either overpressured or underpressured. The abnormal pressures of these reservoirs indicate that water in hydrodynamic equilibrium with outcrop is not the pressuring agent. Instead, hydrocarbons within the tight reservoirs are thought to provide the pressuring mechanism (Spencer, 1987).

Masters (1979) was one of the first to study these unique accumulations, which occur downdip from more permeable, water-wet rocks. Masters (1979) proposed that gases generated in the deep, thermally mature areas of sedimentary basins with low-permeability rocks are inhibited from migrating upward and out of the basin by a capillary seal. Masters (1979) pointed out that low-permeability rocks (<1 mD), with 40 percent water saturation, are only three-tenths as permeable to gas as they are to water, and, at 65 percent water saturation, the rock is almost completely impervious to the flow of gas. The concepts for the development of basin-centered gas accumulations in the Rocky Mountains have been further refined by a number of workers such as Jiao and Surdam (1993), Meissner (1980, 1981, 1984), McPeek (1981), Law (1984), Law and others (1979, 1989), Law and Dickinson (1985), MacGowan and others (1993), Spencer and Law (1981), Spencer (1985, 1987), and Yin and Surdam (1993). In general, the conceptual models suggest that overpressuring, which is commonly encountered in these basin-centered accumulations, is the result of volumetric increases during gas generation in source rocks that are interbedded with sandstone reservoir rocks. Law (1984) suggested that migration distances from source rock to reservoir rock in the basin-centered gas accumulation of the Greater Green River Basin of Wyoming, Colorado, and Utah are generally less than a few hundred feet. Much of the water that originally filled pore spaces in potential reservoirs is driven out by hydrocarbons (Law and Dickinson, 1985). According to Law and Dickinson (1985), the capillary seal is activated as gas replaces water in the pore space, and hence the basin-centered gas accumulations seal themselves as they form. These seals are so efficient that they may be able to maintain abnormally high pressures for tens of millions of years after gas generation has ceased (MacGowan and others, 1993).

Many basin-centered gas accumulations in Rocky Mountain basins are partially to totally underpressured, and it is believed that all of these underpressured areas were overpressured at some time in the past (Meissner, 1978; Law and Dickinson, 1985). Moreover, it is believed that a previous period of overpressuring would have been necessary to drive much of the water out of the system. A change from overpressured to underpressured conditions can occur as a result of cooling related to uplift and erosion or to a decrease in thermal gradient (Meissner, 1978; Law and Dickinson, 1985). Most of the cooling in Rocky Mountain basins has occurred within the last 10 m.y. as the onset of major regional uplift initiated a period of rapid downcutting throughout the region. For a summary of the evidence for late Cenozoic uplift in the Rocky Mountain region, see Keefer (1970) and Larson and others (1975). Overpressured areas became underpressured during cooling as gas contracted and the rate of gas generation decreased (Meissner, 1978; Law and Dickinson, 1985). Surface water enters the basin-centered accumulation through newly created permeability pathways created as pore throats and fractures dilate. According to Meissner (1978) this contraction may ultimately result in a "dead" basin where the basin-centered accumulation has been completely dissipated. Many Rocky Mountain basin-centered gas accumulations have underpressured zones surrounding an overpressured central core indicating that this process has only partially run to completion. The underpressured zone will grade outward into a predominantly water-bearing zone that is in pressure equilibrium with the local hydrodynamic regime. Any gas present in this water-bearing zone will be trapped in conventional reservoirs on anticlinal structures or in stratigraphic pinch-outs.

Levels of thermal maturity define areas where potential source rocks have generated gas at some time in the past and are commonly used as an indirect method of defining the limits of a basin-centered gas accumulation. Masters (1984, p. 27, fig. 25), in a study of the basin-centered gas accumulation in the deep basin of Alberta, indicated that a vitrinite reflectance

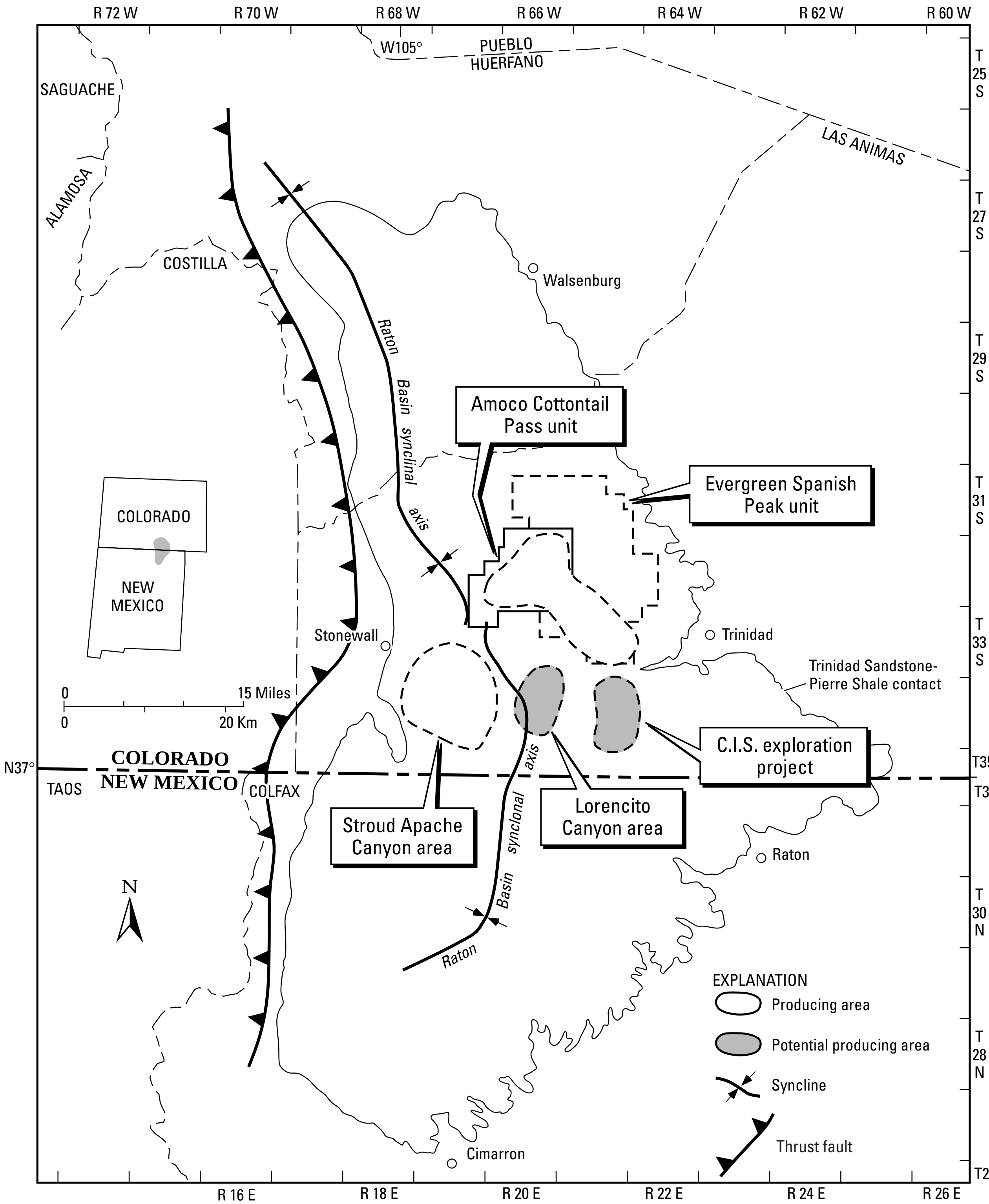

Figure 6. Map showing areas of current coal-bed methane production in the Raton Basin. Adapted from Hemborg (1996).

(Rm) of 1.0 percent corresponds approximately to the limit of the accumulation. In the Piceance Basin of western Colorado, Johnson and others (1987) used a vitrinite reflectance (Rm) of 1.1 percent to define the limits of the basin-centered gas accumulation. Rm values of from 0.73 to 1.1 percent were used to define a transition zone containing both tight reservoirs and reservoirs with conventional permeabilities. Johnson and others (1996, 1999) used these same thermal maturity limits to help define the basin-centered gas accumulation in the Wind River Basin of Wyoming and the Bighorn Basin of Wyoming and Montana. In the Greater Green River Basin of Wyoming, Colorado, and Utah, Law and others (1989) used an Rm of 0.80 percent to define the top of overpressuring in that basin-centered gas accumulation.

Evidence for a Basin-Centered Gas Accumulation in the Raton Basin

Evidence for gas at shallow depths in uppermost Cretaceous and Paleocene strata in the Raton Basin has been documented by Dolly and Meissner (1977), Broadhead (1982, 1991), Rose and others (1986), and Woodward (1987) and is summarized in table 1. According to Dolly and Meissner (1977, p. 259) "...gas flows encountered during the drilling and testing of exploratory and shallow water wells are of a nearly universal nature in sandstones, coals, and fracture zones present in Poison Canyon, Raton, Vermejo, and Trinidad formations." Dolly and Meissner (1977) describe sandstones in these formations as "tight, clay-filled" and similar to productive Cretaceous and Tertiary sandstones in many other Rocky Mountain basins. They cite one well, the Filon no. 1 Golden Cycle in sec. 11, T. 29 S., R. 67 W. that tested 30 MCF of gas from a zone at 1,630 to 1,760 ft in the lower part of the Raton Formation. An unusually low fluid pressure gradient of 0.25 psi/ft was noted by Dolly and Meissner (1977, p. 268) in the tested interval from this well indicating significant underpressuring. They noted that this pressure gradient corresponds to a potentiometric head of approximately 780 ft below the well site. Initial production testing, after fracturing with nitrogen foam and KCl-inhibited water, indicated a flow rate of 75 MCFPD and 1,500 barrels of water per day (BWPD). After 2 months, the well stabilized at about 72 MCFPD and 100 BWPD. It is unclear how much of the initial water production was "frac" water. Although Dolly and Meissner (1977, fig. 13) clearly believed that discrete gas-water contacts existed in the productive lenticular sandstones, the presence of underpressured gas in tight reservoirs is characteristic of many basin-centered gas accumulations in the Rocky Mountain region. Underpressuring indicates that the reservoirs are isolated from the regional ground-water regime.

More recently, Rose and others (1986) used variations in resistivity logs to try to delineate the gas-saturated basin-centered accumulation in just the Trinidad Sandstone in the northern part of the basin. The Trinidad is a marginal marine "blanket-like" sandstone that persists throughout the Raton Basin. This contrasts with the much more lenticular fluvial sandstones found in the nonmarine parts of the Upper Cretaceous and Paleocene section in the basin. Rose and others (1986) suggested that an analog to the Trinidad Sandstone may be the highly gas productive Upper Cretaceous marginal-marine Pictured Cliffs Sandstone in the San Juan Basin to the west. The Pictured Cliffs Sandstone produces gas from stratigraphic traps formed by stratigraphic step-ups toward the northeast (Meissner, 1984).

Regional underpressuring at shallow depths in the Raton Basin has been documented by several workers (Howard, 1982; Geldon, 1990; Close and Dutcher, 1990; Tyler and others, 1995). A potentiometric surface map of the Vermejo-Raton aquifer constructed by Stevens and others (1992) and published by Tyler and others (1995, p. 170) indicates that underpressured conditions exist in the main coal-bearing intervals throughout most of the basin. Tyler and others (1995, p. 169–170) state that the pressure regime in the basin is poorly understood but list some of the possible causes for this underpressuring. They noted that low pressures indicate that the rocks are isolated from topographically high recharge areas along the west margin of the basin and suggest that low permeability in the sandstones and coal beds may limit hydrologic connection.

Discussion

It has long been suspected that a significant basin-centered type gas accumulation is present in Upper Cretaceous and Paleocene sandstones in the Raton Basin. Few attempts have been made to develop these resources because of the lack of gas pipelines out of the basin. Success with the current coal-bed methane exploration in the basin will eventually alleviate this pipeline problem and should lead to new attempts to develop these sandstone gas resources. Gas resources found in coal beds and in adjacent sandstone reservoirs are developed concurrently in many Rocky Mountain basins.

It is suggested here that the widespread gas shows and abnormally low pressures encountered in the Vermejo and Raton Formations indicate a basin-centered gas accumulation developed in these units. Using analogs from other Rocky Mountain basins, intervals where thermal maturities of source rocks are greater than an Rm of 1.1 percent were probably once overpressured and largely gas saturated. At lower levels of thermal maturity, both gas-charged and water-wet sandstones were probably present. The big unanswered question in the Raton Basin is how much of the original accumulation is still intact? Present-day depths to the top of the Trinidad Sandstone are less than 3,500 ft throughout most of the basin (fig. 7) except in the immediate vicinity of the Spanish Peaks where it is deeper than 9,000 ft. The widespread reports of underpressured gas-saturated sandstones at shallow depths suggests that

Table 1. List of wells in the Raton Basin that tested gas of had gas shows in sandstones of Upper Cretaceous and Paleocene age.

[Data compiled from Dolly and Meissner (1977), Broadhead (1982, 1991), Rose and others (1986), and Woodward (1987). TKr, Raton Formation; Kv, Vermejo Formation; Kt, Trinidad Sandstone; Kp, Pierre Shale]

Operator	Well	Location	Remarks	Source
		Colorado		
Filon Expl.	1 Bohlman	28S-67W-4	No DST's. Gas shows from TKr, Kv.	Dolly and Meissner (1977)
Kimbark Oper.	1 Dog Spr.	28S-68W-16	Rec. gas from DST from Kt & Kp.	Rose and others (1986)
Pan Amer. Pet.	M-1 State	29S-66W-33	DST gas show fromTKr.	Dolly and Meissner (1977)
Pan Amer. Pet.	1 Dick Realty	29S-67W-3	Rec. gas from DST from TKr & Kv.	Dolly and Meissner (1977)
Pan Amer. Pet.	1 Rohr	29S-67W-9	Rec. gas from DST from TKr & Kv.	Dolly and Meissner (1977)
Filon Expl.	1 Golden Cycle	29S-67W-11	Rec. gas from DST from TKr. Gas show in Tpc.	Dolly and Meissner (1977)
Clark & Perkins	1 Goemmer	29S-67W-11	Rec. gas from DST from TKr (?).	Dolly and Meissner (1977)
HBB Inc.	22-7 Goemmer	30S-68W-7	Shut-in gas well. Perfs. 4898–5100, Kt &Kp.	Completion card.
Filon Expl.	1 Zele's Hope	31S-65W-31	Gas shows during drilling.	Dolly and Meissner (1977)
HBB Inc.	1 Schultz	31S-67W-27	Rec. gas from Kt.	Rose and others (1986)
Wood, et al.	1 State	32S-67W-36	Shut-in gas well. Prod. zone; 1935-2135, Kv.	Completion card.
		New Mexico		
Odessa Nat. Corp.	4-X W.S. Ranch	29N-18E-12	Gas show in Kp.	Completion card.
Amer. Fuels	1 W.S. Ranch	29N-19E-6	Gas shows in Kp.	Woodward (1987)
Odessa Nat. Corp.	3 W.S. Ranch	29N-19E-24	Gas shows in Kp.	Woodward (1987)
Odessa Nat. Corp.	1 W.S. Ranch	30N-18E-16	Gas shows in Kv & TKr.	Woodward (1987)
Amer. Fuels Corp.	3 W.S. Ranch	30N-18E-22	Gas shows in Kp.	Woodward (1987)
Odessa Nat. Corp.	5 W.S. Ranch	30N-18E-22	Gas shows in Kp & Kt.	Completion card.
Odessa Nat. Corp.	2 Vermejo	30N-19E-16	Gas shows in Kp.	Woodward (1987)
Odessa Nat. Corp.	2 W.S. Ranch	30N-20E-30	Gas shows in Kp.	Woodward (1987)
Continental Oil	1 St. Louis	30N-22E-13	Gas shows in Kp.	Completion card.
Penzoil Co.	2 Vermejo	31N-17E-1	Shut- in gas well. Prod. zone, Kp, 691 MCFD.	Completion card.
Penzoil Co.	1 Vermejo Ranch	31N-17E-34	Gas show in Kt.	Broadhead (1982)
Penzoil Co.	311 M Castle Rock	31N-18E-31	Extensive oil shows in TKr & Kv.	Broadhead (1991)
Continental Oil	2 St. Louis	31N-21E-26	Oil in fractures in Kp.	Woodward (1987)
Pan Amer. Pet.	1 Kaiser Steel	31N-22E-31	Gas show in Kt.	Completion card.

a largely intact basin-centered gas accumulation still exists in the Trinidad Sandstone, Vermejo Formation, and Raton Formation.

Gas from coal beds and gas from sandstones are typically developed together in Rocky Mountain basins. The San Juan Basin of New Mexico and Colorado has by far the most successful coal-bed methane production in the United States. Yet the original exploration targets were not the coal beds but the adjacent sandstones, which were typically gas charged (Dugan and Williams, 1988). Only after gas wells started experiencing increases in rates of production did operators begin to suspect that adjacent coal beds were contributing significantly to production. At Grand Valley field in the Piceance Basin of western Colorado, lenticular fluvial sandstones interbedded with coals of the Cameo-Fairfield coal zone have become the principal exploration target in the field, although both coals and sandstones were originally targeted (Reinecke and others, 1991). Sandstones adjacent to the thick lower Tertiary coal beds in the Powder River Basin of Wyoming and Montana are typically gas charged (Hobbs, 1978) and are increasingly becoming targets for exploration. Gas from coal beds and adjacent sandstones are typically comingled in the Upper Cretaceous

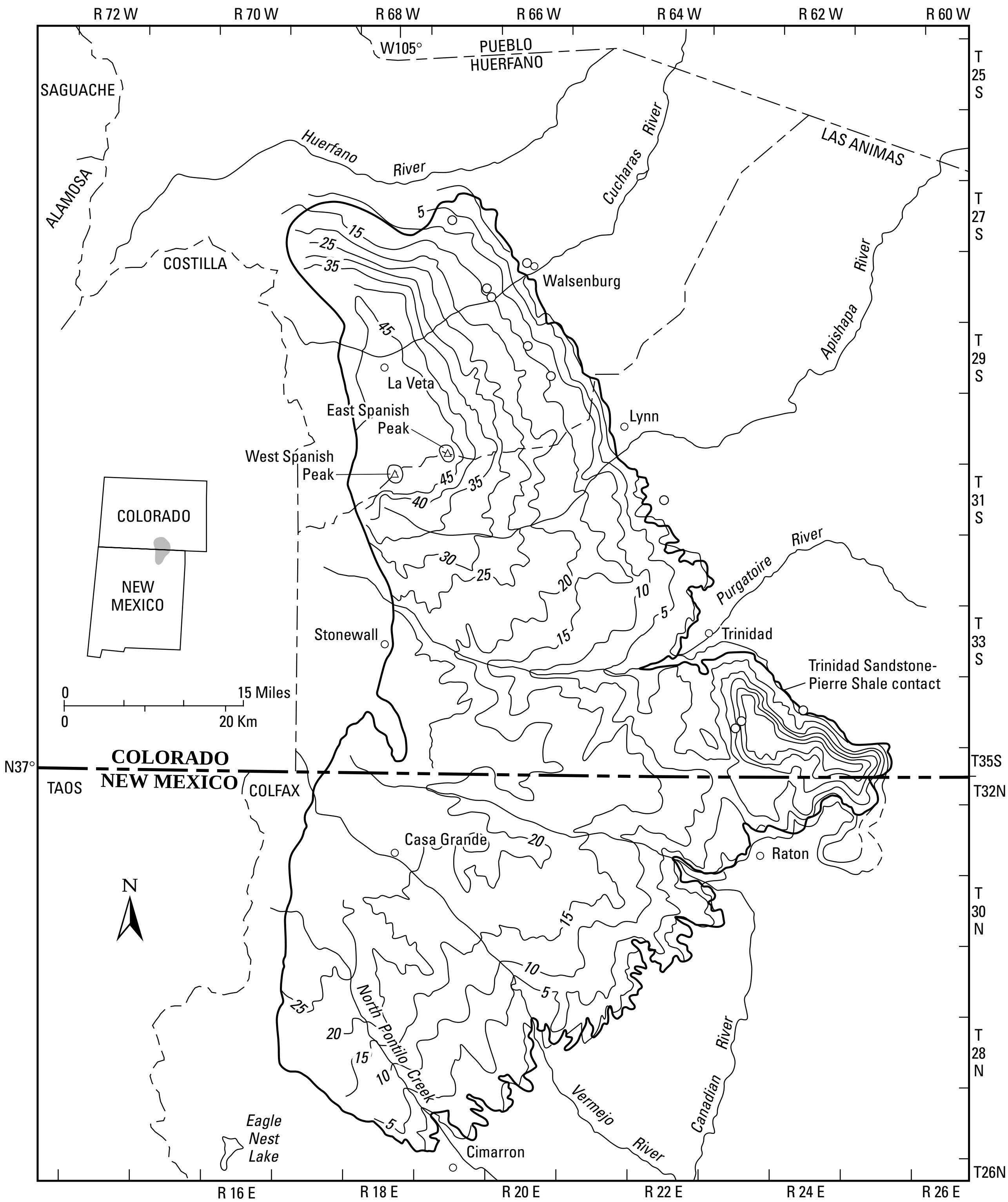

Figure 7. Approximate depths (in hundreds of feet) to the top of the Trinidad Sandstone. Map constructed by overlaying the structure contour map of the top of the Trinidad Sandstone (Tyler and others, 1995, fig. 113) on State topographic maps for Colorado and New Mexico.

Ferron Sandstone Member of the Mancos Shale in the Wasatch Plateau of central Utah.

Within a few years, the Raton Basin may well evolve into both a coal-bed methane play and a basin-centered sandstone gas play. At present, there appears to be no identified production in the Raton Basin from sandstones within the basin-centered accumulation, and it is difficult to assess how successful this play will be. A more comprehensive study of this potential gas resource should be made once reliable information is available concerning sandstone-production characteristics in the basin.

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Manuscript approved for publication May 21, 2001
Published in the Central Region, Denver, Colorado
Editing, page layout, photocomposition—Richard W. Scott, Jr.
Cover design—Carol A. Quesenberry
Graphics by the authors