U.S. DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

SCIENTIFIC INVESTIGATIONS MAP 2925
Version 1.0

GEOLOGIC MAP AND COAL STRATIGRAPHY OF THE DOTY MOUNTAIN QUADRANGLE,EASTERN WASHAKIE BASIN, CARBON COUNTY, WYOMING

By
R.D. Hettinger and J.G. Honey
2006

Base from U.S. Geological Survey, 1982
Projection and 10,000-foot grid ticks: Wyoming coordinate system, east central zone (transverse Mercator)
1000-meter Universal Transverse Mercator grid, zone 13
1927 North American Datum

SCALE 1:24000
CONTOUR INTERVAL 20 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929

Geology mapped by R.D. Hettinger and J.G. Honey, 1976 and 1977
Geologic linework digitized by Anna K. Scarbrough and Joseph A. East
Edited by Alessandro J. Donatich, Central Publications Group

DESCRIPTION OF MAP UNITS

Eolian sand dunes (Holocene and (or) Pleistocene)—Wind-blown sand deposited along southwest margin of a large dune field that extends northeast into the Sand Hills region of the adjoining Sulphur Springs 7.5-minute quadrangle (fig. 1). Entire dune field is about 10 mi long and 3 mi wide. Additional small isolated eolian deposits are widespread throughout quadrangle but were not mapped

Colluvium and eolian sand, undifferentiated (Holocene and (or) Pleistocene)—Slope wash, soil cover, and wind-blown sand. Colluvium and eolian deposits are widespread across quadrangle but are mapped only locally in southwestern part of quadrangle where they obscure coal beds

Alluvium and colluvium, undifferentiated (Holocene and (or) Pleistocene)—Alluvium and alluvial-fan, slope-wash, and slump deposits located along upper reaches of alluvial valleys, on slopes that flank alluvial valleys, and along courses of intermittent streams; locally may include small areas of exposed bedrock

Alluvium (Holocene and (or) Pleistocene)—Clay, silt, sand, and gravel deposits along Muddy Creek

Terrace deposits (Holocene and (or) Pleistocene)—Thin, unconsolidated to locally cemented deposits of silt, sand, and gravel; pebbles and cobbles are abundant and boulders are rare. Pebbles are composed of quartz, chert, ironstone, and dark-gray limestone. Cobbles are composed of a variety of rock types including sandstone, chert, ironstone, dark-gray limestone, fossiliferous limestone, gneiss, schist, white and red quartz and quartzite, white granite, and dark-gray, black, and green mafic igneous rock. Boulders are as much as 1.5 ft across and composed of white quartzite, conglomeratic quartzite, and white and pink granite

Landslide deposits (Holocene and (or) Pleistocene)—Mixed debris of soil and bedrock, mainly in areas underlain by the lower member of the Lance Formation. Landslide deposits on northwest side of Doty Mountain include younger deposits of disturbed bedding, rotated blocks, slope wash, and mudslides due to creep and mass wasting. These younger deposits overlie older dissected deposits that might have resulted through mass failure. May include local areas of undisturbed bedrock, particularly along creek bottoms

Browns Park Formation(?) (Miocene(?) and Oligocene(?))—Isolated deposit of unconsolidated gravel, less than 5 ft thick, at elevation of 7,660 ft on Doty Mountain. Consists of sand, pebbles, and cobbles of quartz, chert, gray limestone, white granite, white, green, and red quartzite, and boulders as much as 3 ft across of white quartzite, conglomeratic quartzite, and granite. Unit is thought to be an erosional remnant of the Browns Park Formation that was mapped by Luft (1985) at an elevation of 7,750 ft about 6 mi east of Doty Mountain. However, it may represent a younger Quaternary gravel derived from the Browns Park Formation

Wasatch Formation (Eocene)

Main body—Only the lower 120 ft of the main body of the Wasatch Formation is exposed locally along the west boundary of the Doty Mountain 7.5-minute quadrangle. The Wasatch is about 1,220 ft thick 8 mi south of the quadrangle (Hettinger and Honey, 2005). Where exposed in the quadrangle, the main body is predominantly light-gray to brownish-gray sandy siltstone and mudstone with only scattered varicolored (light-gray, red, maroon, and green) beds of mottled mudstone. A widespread conglomeratic sandstone at the base of the Wasatch marks an abrupt coarsening and unconformable contact with underlying strata (Honey and Hettinger, 2004) (see basal contact of Wasatch on type section 3, fig. 3). Near the Dad arch (fig. 1), the basal zone contains a lenticular conglomerate and conglomeratic sandstone, locally as much as 12 ft thick, with chert pebbles in a matrix of coarse-grained, iron-stained sandstone. About 2 mi north of the Dad arch, the basal conglomerate grades to a fine-grained to very coarse grained arkosic sandstone as much as 30 ft thick. This arkosic sandstone is best exposed in the vicinity of Pine Butte (sec. 10, T. 17 N., R. 92 W.), where a 30-ft-thick, multistoried, trough-crossbedded bituminous sandstone overlies an erosional surface that is scoured into the Fort Union Formation. The sandstone at Pine Butte contains feldspar granules, flat siltstone clasts as much as 2 in. across, and carbonaceous shale and mudstone clasts as much as 1 ft across. The basal conglomeratic zone extends northward from the Doty Mountain quadrangle and is equivalent stratigraphically to friable, grayish-yellow, medium- to coarse-grained, granular arkosic sandstone that lies directly over the Cherokee coal zone of the Paleocene Fort Union Formation (fig. 1). Sanders (1975) considered the arkosic sandstone to be equivalent to the Paleocene-Eocene Battle Spring Formation mapped in the Great Divide Basin by Pipiringos (1961)

Fort Union Formation (Paleocene)

Overland Member—Light- to medium-gray sandstone, mudstone, and siltstone; less common grayish-brown to dusky-purple ironstone and grayish-brown carbonaceous shale. Forms light-gray to white fluted badlands, rounded hills, and cuestas. Includes a medium-grained to very coarse grained basal sandstone overlain by a thick, fine-grained interval of sandstone, siltstone, and mudrock. Chert pebbles and feldspar granules in the basal sandstone mark an abrupt increase in grain size from that of the underlying China Butte Member; the contact between the basal sandstone and the China Butte Member is probably unconformable (Honey and Hettinger, 2004).

The Overland Member is well exposed in the Doty Mountain 7.5-minute quadrangle, with the best exposures in the Cedars area (fig. 1). The member is about 925–1,000 ft thick where exposed and about 1,100 ft thick where drilled in the northwestern part of the quadrangle (drill hole DH-17 in sec. 10, T. 17 N., R. 92 W.). The basal sandstone thickens from 25 to 55 ft in the southwestern part of the quadrangle (Cedars area) to as much as 390 ft where it was drilled in the northwestern part of the quadrangle. The Overland Member is approximately equivalent to the upper part of the Fort Union Formation as described along the east flank of the Washakie Basin by Swain (1957).

At its type section in sec. 34, T. 17 N., R. 92 W., the member is about 925 ft thick; its basal sandstone is about 55 ft thick and the fine-grained upper part is about 870 ft thick (fig. 3). The basal sandstone is massive to trough crossbedded, medium to very coarse grained, pebbly, and granular. The fine-grained upper part is dominated by sandy siltstone, sandy shale, shaly siltstone, and mudstone, but it also contains several lenticular sandstone bodies as much as 15 ft thick. Sandstone in the upper part is fine to medium grained, feldspathic, and generally massive or bioturbated, and locally trough and planar tabular crossbedded. Minor beds of carbonaceous shale and sandy or pisolitic ironstone are less than 2 ft thick. Crayfish burrows are locally present in all lithologies (Hasiotis and Honey, 2000). A USGS palynological sample (D5963), collected about 405 ft above the base of the Overland Member (fig. 3), contains late Paleocene palynomorphs typical of zone P5 of Nichols and Ott (1978) (Hettinger and others, 1991)

China Butte Member—Sandstone, mudrock, and coal, typically arranged in thick fining-upward successions. These rocks were previously included in the lower Fort Union Formation as described along the eastern flank of the Washakie Basin by Swain (1957). Fossils of roots, coalified plant fragments, leaves, wood, bone fragments, fish scales, and isolated burrow traces are present locally in all lithologies. Sandstone is light whitish gray, light yellow gray, light orange brown, fine to medium grained, and less commonly very fine or coarse grained. Sandstone is trough and planar cross-stratified, ripple laminated, convoluted, or massive. Sandstones in lower part of fining-upward successions are typically 30–150 ft thick, laterally continuous, and multistoried; individual stories are 10–50 ft thick, laterally and vertically amalgamated, and channel form. Mudrock in upper parts of fining-upward successions are fissile and composed of light- to medium-gray, dusky-brown, or black siltstone, mudstone, and carbonaceous shale interbedded in laterally continuous units 15–230 ft thick. Encased in the mudrock are orange-brown to light-gray, very fine grained to fine-grained, trough-crossbedded, and ripple-laminated sandstones in discontinuous beds less than 1 ft thick and lenticular bodies as much as 10 ft thick. Mudrock units also contain laterally continuous beds of coal 1–33 ft thick (including partings); the coal is commonly burned to red and orange clinker on outcrop. The

China Butte Member is interpreted as deposits of fluvial channels, flood plains, and mires.

The lower part of the China Butte Member is characterized by thick sandstone previously placed in (1) the Upper Cretaceous Lance Formation by Swain (1957), (2) the Fort Union Formation by Henderson (1962), and (3) the upper zone of the unnamed Cretaceous and Tertiary sandstone unit by Hettinger and others (1991). The sandstone is white, multistoried and medium to coarse grained, and locally contains rare scattered chert pebbles that are more common near its base. It is 220 ft thick in the southern part of the quadrangle, and about 450 ft thick in the northern part of the quad-rangle where it includes a few thin beds of shale and a 0.5-ft-thick coal bed.

The base of the China Butte Member is a laterally persistent, 2- to 4-ft-thick conglomerate and conglomeratic sandstone characterized by abundant pebbles in a coarse-grained, iron oxide-cemented sandstone matrix; pebbles consist of gray and black chert and lesser amounts of white and pink quartzite and quartz, and porphyritic felsic igneous rock. The conglomerate commonly forms a resistant, reddish-brown ledge that overlies an unconformity between Cretaceous and Tertiary strata (Honey and Hettinger, 1989a; Hettinger and others, 1991; Hettinger and Kirschbaum, 1991; Honey and Hettinger, 2004). However, at the Cedars area (fig. 1), the reddish-brown ledge is absent and the base of the member is represented by white conglomeratic sandstone. The stratigraphic position of the Cretaceous-Tertiary unconformity is bracketed by USGS palynological samples D6470, D6474, and D6860. Sample D6474 was collected about 85 ft below the conglomerate horizon in the Peach Orchard Flats quadrangle (see Honey and Hettinger, 2004); sample D6860 was collected about 50 ft above the conglomeratic horizon in the Blue Gap quadrangle (see Hettinger and Honey, 2005); and sample D6470 was collected about 360 ft above the conglomeratic horizon in the Doty Mountain quadrangle (near measured section 20, this report). Palynomorphs from the collections were identified in Hettinger and others (1991). Early Paleocene palynomorphs typical of zone P2 of Nichols and Ott (1978) were identified from samples D6860 and D6470, and Late Cretaceous (Maastrichtian) palynomorphs were identified from sample D6474.

The China Butte Member is about 1,065 ft thick in the southern part of the quadrangle at its type section in secs. 3 and 4, T. 16 N., R. 92 W. (fig. 3). The member is about 1,700 ft thick where exposed in the northern part of the quadrangle, and about 1,565–1,760 ft thick in the subsurface north of Muddy Creek.

Mapped coal zones in the China Butte Member (fig. 3) include, from youngest to oldest, the Fillmore Ranch (FR), local unnamed coal beds (C), Muddy Creek (containing coal beds MC3, MC1, MC, and MClower), Separation Creek (containing coal beds SC1 and SC2), lower Separation Creek (lowerSC), Wild Cow (WC, containing coal beds WC1 and WC2), lower Olson Draw (containing coal beds lower OD1 and lower OD2), Red Rim (RR), and Red Rim lower (RRlower). The Fillmore Ranch, Muddy Creek, Separation Creek, Olson Draw, and Red Rim coal zones were originally named and mapped in the Seaverson Reservoir and Fillmore Ranch 7.5-minute quadrangles (fig. 1) by Edson (1979) and Honey and Hettinger (1989b). Coal-zone nomenclature of Honey and Hettinger (1989b) is shown along the right margin of the coal correlation chart (sheet 2). Based on detailed mapping and correlation studies, the names have been applied to coal zones in the Doty Mountain 7.5-minute quadrangle. The following modifications have been made to the established coal-zone nomenclature of Edson (1979) and Honey and Hettinger (1989b):

(1) The Muddy Creek coal bed of Edson (1979) and Honey and Hettinger (1989b) is one of several coal beds that occupy an interval of mudrock and sandstone referred to as the Muddy Creek coal zone in this report. The Muddy Creek coal zone contains the MC3, MC1, MC, and MClower coal beds, which were mapped individually. The Muddy Creek coal bed of Edson (1979) is the MC coal bed in the northern part of the Doty Mountain 7.5-minute quadrangle. The outcrop of the Muddy Creek coal bed was mapped incorrectly by Edson (1979) near the boundary between the Doty Mountain and Seaverson Reservoir 7.5-minute quadrangles. We have therefore revised its position where it extends into the Doty Mountain quadrangle.

(2) The Wild Cow coal zone is informally named for coal-bearing strata located between the lower Olson Draw and lower Separation Creek coal zones in the Doty Mountain 7.5-minute quadrangle; it takes its name from Wild Cow Creek in the Blue Gap 7.5-minute quadrangle

Lance Formation (Upper Cretaceous)

Red Rim Member—Mainly very light gray and white, fine- to coarse-grained, quartz-rich sandstone containing grains of feldspar, clay altered from feldspar, and black chert. Chert pebbles are common in upper part of member. Sandstone is soft and friable, forming valley floors, covered slopes, and cliffs. Laterally continuous, 20- to 170-ft-thick units of sandstone are separated by 5- to 15-

ft-thick units of brown and gray mudrock. The thickness and abundance of sandstone increases upward through the member as mudrock decreases. Sandstone units consist of vertically and laterally amalgamated, channel-form bodies that are 5–20 ft thick, massive to trough crossbedded, ripple laminated, and capped by thin ironstone ledges; iron-oxide concretions several feet across are common. Basal lags of flat claystone clasts as much as 1 in. long and blocks of mudrock several feet across are common. The sandstone bodies are interpreted as fluvial channel deposits. The member also displays an overall coarsening-upward grain size, with the lower 600 ft being fine to medium grained and the upper 100 ft being medium to very coarse grained and pebbly. Pebbles are chert and are c–a in. in diameter; they are generally along foresets, in lag, or as isolated clasts in sandstone matrix. Channel bodies in the upper 100 ft display strong crosscutting relations. The Red Rim Member is about 685 ft thick at its type section in sec. 3, T. 16 N., R. 92 W. (fig. 3). It thickens from south to north and is about 740–1,100 ft thick in oil and gas wells in the northwestern part of the quadrangle. At the type section, the basal contact was placed at the first major sandstone in a succession of thick laterally continuous sandstones that characterize the member. The member appears to intertongue with the lower member of the Lance Formation, but exact stratigraphic relations are uncertain due to poor exposures.
Late Cretaceous (Maastrichtian) palynomorphs were identified in USGS palynomorph samples D5099-A, D5099-B, and D5099-C, collected about 65, 80, and 260 ft above the base of the member, respectively (figs. 2, 3). Sample localities are shown on the geologic map (sheet 1) as well as stratigraphic section 40 on sheet 2. Samples D5099-A and D5099-B were collected about 800 ft south of section 40 and projected to the section by tracing strata. Late Cretaceous (Maastrichtian) palynomorphs were also identified in USGS palynomorph sample D6474, collected 85 ft below the top of the member about 10 mi south of the Doty Mountain quadrangle in the Peach Orchard Flats quadrangle (fig. 1) (Honey and Hettinger, 2004). Palynomorphs from the collections were identified in Hettinger and others (1991)
Lower member–Predominantly thin, interbedded, yellow-brown, dusky-brown, medium- to dark-gray, and greenish-gray mudrock that includes claystone, siltstone, clayey shale, and carbonaceous shale. Plant fragments are common in the mudrock, and leaf impressions are present in a few interbedded sandstones. Upper part of member is poorly

exposed; oil and gas wells in the northwestern part of the quadrangle indicate that the upper 250–500 ft is dominated by 10- to 200-ft-thick sandstones separated by 10- to 70-ft-thick units of mudrock. Stratigraphically equivalent sandstones exposed in the Blue Gap and Peach Orchard Flats quadrangles (fig. 1) are yellow brown to very light gray, fine to medium grained, massive or trough crossbedded, lenticular, and multistoried (Honey and Hettinger, 2004; Hettinger and Honey, 2005). The sandstones contain the first appearance of detrital chert above the Lewis Shale (Hettinger and others, 1991). Sandstone is a minor component in the lower 950–1,150 ft of the member, where it typically forms purplish-brown to gray, lenticular, very fine grained to fine-grained, ripple-laminated beds less than 5 ft thick. The lower part also contains rare lenticular bodies of yellow-gray to very light gray, very fine grained to fine-grained, and trough-crossbedded sandstone as much as 50 ft thick. The basal 50 ft contains lenticular beds of coquina and two or three unnamed beds of coal that range between 1 and 8.5 ft thick. A 3-ft-thick coal bed is also present locally 250 ft above the base of the lower member.

The lower member of the Lance Formation is interpreted to have accumulated in fluvial, flood-plain, coastal-plain, and lagoonal environments. Coastal-plain and mire deposits in the basal 50 ft intertongue with shoreface strata in the underlying Fox Hills Sandstone. The lower member is about 1,260–1,450 ft thick where it was drilled in the northwestern part of the quadrangle. About 10 mi south of the Doty Mountain quadrangle, in secs. 28, 29, and 33, T. 15 N., R. 92 W., the lower member is about 1,675 ft thick on outcrop (Honey and Hettinger, 2004)

Fox Hills Sandstone, upper part of the Lewis Shale, and Dad Sandstone Member of the Lewis Shale, undivided (Upper Cretaceous)—The strata were mapped as a single unit because the upper part of the Lewis Shale is poorly exposed and difficult to separate from adjacent strata. The Fox Hills Sandstone was deposited in shallow-marine, barrier-bar, and beach environments, and the Lewis Shale was deposited in a deep-water marine environment (Gill and others, 1970). Combined thickness ranges from 2,050 to 2,180 ft in oil and gas wells listed in table 1. Individual formations and members are described below.

The Fox Hills Sandstone is dominated by interbedded thick to thin sandstone and shale units typically stacked in coarsening-upward successions; the formation is 160–300 ft thick in outcrop (Henderson, 1962) and 300–390 ft thick in the subsurface. Stratigraphic sections by Henderson (1962) indicate outcrops contain one to three sandstones, each about 15–100 ft thick; sandstones are separated by 10- to 160-ft-thick units of thinly interbedded sandstone and shale. In oil and gas wells, the Fox Hills contains five to nine 10- to 90-ft-thick sandstones separated by 5- to 70-ft-thick units of thinly interbedded sandstone and shale. Exposures of sandstone are generally grayish orange to yellowish gray, concretionary, very fine to medium grained, and generally massive but also trough crossbedded and ripple laminated; oyster shells and trace fossils of Ophiomorpha are common. Shales are gray, silty, and locally carbonaceous, and contain thin beds of fine-grained sandstone. One or two coal beds, 0.7–4.0 ft thick, are present 60–90 ft below the top of the formation. The base of the Fox Hills is gradational with the underlying Lewis Shale.

The upper part of the Lewis Shale is poorly exposed. Witton (1999) described exposures 3 mi south of the Doty Mountain quadrangle, in secs. 24 and 25, T. 16 N., R. 92 W., in the Blue Gap quadrangle (fig. 1). There, the upper part consists of olive-gray, silty shale with thin beds of silty, very fine grained sandstone. Sandstone beds are massive to parallel laminated, have abundant slump features and nonscoured bases, and extend several to several hundred feet laterally. Witton (1999) interpreted the sandstones as turbidite deposits that accumulated on the upper slope between the shelf and deep basin. In the subsurface of the Doty Mountain quadrangle, the upper part of the Lewis Shale is 255–480 ft thick and characterized by several coarsening-upward successions of shale and siltstone; sandstones as much as 30 ft thick cap some successions.

The Dad Sandstone Member of the Lewis Shale is poorly exposed, forming covered valleys with small rounded hills and cuestas. It consists of thick, pale-yellowish-gray and light-brown, locally concretionary sandstones in olive-gray mudrock. Mudrock comprises thinly interbedded to interlaminated very fine grained sandstone, siltstone, and mudstone. Oil and gas wells in the Doty Mountain quadrangle indicate the member contains between 400 and 600 ft of net sandstone; sandstone-dominated intervals as much as 250 ft thick are common. Member is 1,250–1,560 ft thick where drilled in the northwestern part of the quadrangle, but thins to the south and is about 1,050 ft thick (spanning depths of 2,420 and 3,470 ft) in the Tom Brown No. 1 Federal drill hole located 2 mi south of the quadrangle in sec. 22, T. 16 N., R. 92 W. Witton (1999) described the Dad Sandstone Member about 3 mi south of the Doty Mountain quadrangle, in secs. 24 and 25, T. 16 N., R.

92 W., as follows: (1) the upper part contains laterally discontinuous channel-fill sandstones with deeply scoured bases, basal lags, and multiple channel fills consisting of massive to parallel-laminated sandstone that locally exhibits soft-sediment deformation, and (2) the middle and lower parts contain flat-based, massive to parallel-laminated, or convoluted, laterally continuous, sheet sandstones. The member, which intertongues with the underlying lower part of the Lewis Shale, was interpreted as a suspension fallout and turbidite deposit in a marine environment (Perman, 1990; Pyles and Slatt, 2000; Witton 1999)

Lower part of the Lewis Shale (Upper Cretaceous)—Dark-gray sandy shale with a few thin continuous sandstones. The sandstones probably extend laterally into the Dad Sandstone Member. Only the upper 250 ft are exposed in the southwestern part of the quadrangle. Drill holes indicate that the lower part of the formation is 720–820 ft thick in the southern part of the quadrangle (secs. 11 and 12, T. 16 N., R. 92 W.), 570–600 ft thick in the northwestern part of the quadrangle, and 820 ft thick at the Nova Petroleum Muddy Creek 18-1 drill hole located in sec. 18, T. 17. N. R. 91 W. The lower part of the Lewis Shale intertongues with the underlying Upper Cretaceous Almond Formation of the Mesaverde Group

Contact—Approximately located. Dashed where covered or inferred

Coal bed or coal zone—Solid line where approximately located; long dash across poorly exposed area where presence is inferred from aerial photographs, drill holes, coal flour, or animal burrows; short dash where inferred beneath mapped surficial deposits. Abbreviations: Fillmore Ranch coal zone (FR); local unnamed coal beds (C); Muddy Creek coal zone (containing coal beds MC3, MC1, MC, and MClower); Separation Creek coal zone (containing coal beds SC1 and SC2); lower Separation Creek coal zone (lowerSC); Wild Cow coal zone (WC, containing coal beds WC1 and WC2); lower Olson Draw coal zone (containing coal beds lower OD1 and lower OD2); Red Rim coal zone (RR); and Red Rim lower coal zone (RRlower). South of measured section 41, coal beds MC1 and MC3 are mapped with a single line labeled MC1,3. Cretaceous coals are not named

Clinker—Burned coal bed and baked rocks

Large area of clinker

Fault—Long dash where approximately located; short dash where inferred; queried where uncertain. Bar and ball on downthrown side

Anticline—Showing crestline and direction of plunge.
Approximately located; dotted where concealed
Strike and dip of beds
Measured on outcrop
Inclined
Vertical
Measured photogrammetrically on a computerized PG-2 plotter—Inclined
USGS palynomorph locality
Drill hole—Showing number on geologic map (sheet 1), coal correlation chart (sheet 2), and table 1
Line of measured stratigraphic section—Showing number on geologic map (sheet 1) and coal correlation chart (sheet 2)
Short measured section of coal bed or coal zone—Showing number on geologic map (sheet 1) and coal correlation chart (sheet 2); leader points to measured section locality

INTRODUCTION

The geology of the Doty Mountain 7.5-minute quadrangle, Carbon County, Wyoming (sheet 1), was mapped in 1976—1978 to acquire detailed data on Upper Cretaceous and Paleocene coal-bearing strata in the eastern part of the Washakie Basin (fig. 1). The geology was initially plotted in the field onto aerial photographs at scales of about 1:20,000, 1:29,000, and 1:36,000, as well as on the 1:62,500-scale topographic base of the 1957 Doty Mountain 15-minute quadrangle map. Coal beds and stratigraphic sections were trenched and measured with a Jacob's staff and tape. Emphasis was on coal-bearing strata in the Paleocene Fort Union Formation and Upper Cretaceous Lance Formation. Subsurface coal in the Upper Cretaceous Mesaverde Group was not studied. Our preliminary coal correlation charts and preliminary maps of coal outcrops and faults were shown on planimetric base maps by the Dames and Moore Company (1979; their plates 1 and 3) to show the coal stratigraphy in the quadrangle. Love and Christiansen (1985) also included our unpublished mapping on the Geologic Map of Wyoming. We subsequently transferred the geology onto the 1:24,000-scale topographic base map of the 1982 Doty Mountain 7.5-minute quadrangle from the aerial photographs using a PG-2 stereoplotter. This report shows the geology we mapped on a topographic base and revises our coal correlations that were shown by Dames and Moore Company (1979); it also includes additional stratigraphic sections we measured in 1988.

Measured sections of coal-bearing strata in the Fort Union and Lance Formations are shown on sheets 1 and 2. Also shown are lithologic interpretations of geophysical logs recorded from twenty drill holes (table 1 on sheet 2); included are seven oil and gas wells, six coal-test holes drilled in 1977 and 1978 by the U.S. Geological Survey (USGS), and seven coal-test holes drilled by the Rocky Mountain Energy Company and Union Pacific Corporation. Geophysical logs for UGSG drill holes DM-D1 and DM-D2 (DH-2 and DH-3, respectively, on table 1) are shown in Hettinger and Brown (1979). Geophysical logs for USGS drill holes DL-D1, DM-3, DM-4, and DM-5 (DL-D1, DH-10, DH-9, and DH-11, respectively, on table 1) are available on microfiche through M.J. Systems, 5085 Oakland Street, Denver, CO, 80239.

About 6,700 ft of sedimentary strata are exposed in the Doty Mountain 7.5-minute quadrangle (fig. 2). Thicknesses of formations and members in figure 2 are based on measured surface sections as well as selected drill holes listed in table 1. Included are marine and shoreface deposits of the Upper Cretaceous Lewis Shale and Fox Hills Sandstone, and continental deposits of the Upper Cretaceous Lance Formation, Paleocene Fort Union Formation, Eocene main body of the Wasatch Formation, and Oligocene(?) and Miocene(?) Browns Park Formation(?). The Lewis Shale overlies the Upper Cretaceous Almond Formation of the Mesaverde Group, which is exposed east of the quadrangle. The Lewis Shale consists of a lower part, the middle Dad Sandstone Member, and an upper part; a principal reference section was described by Gill and others (1970) about 10 mi south of the quadrangle. The Lance Formation consists of a lower member and the Red Rim Member, and the Fort Union Formation consists of the China Butte, Blue Gap, and Overland Members (Honey and Hettinger, 2004). The type sections of the Red Rim, China Butte, and Overland Members are in the Doty Mountain and adjacent Duck Lake 7.5-minute quadrangles and detailed measured sections are shown in figure 3. With the following exceptions, all of the previously described formations and members were mapped in the Doty Mountain 7.5-minute quadrangle: (1) the Dad Sandstone Member, upper part of the Lewis Shale, and Fox Hills Sandstone were mapped as a single unit because the upper part of the Lewis Shale is poorly exposed, very sandy, and difficult to distinguish from its adjacent strata; (2) the Blue Gap Member pinches out in the vicinity of the Dad arch (fig. 1) and was not mapped in the quadrangle; however, its equivalent strata is included within the uppermost 20 ft of the China Butte Member in the southwestern part of the quadrangle.

Strata in the Doty Mountain 7.5-minute quadrangle generally strike northeast-southwest and dip 3∞–30∞ northwest. These rocks lie on the northern limb of the east-west-trending and westwardly plunging Dad arch (fig. 1), which is located immediately south of the quadrangle. Beds in the southwestern part of the quadrangle, in the Cedars area (fig. 1), are oriented approximately north-south and dip to the west, due to folding near the crest of the Dad arch. Strata in the northwestern part of the quadrangle also strike approximately north-south to slightly northeast-southwest and dip to the west or northwest, owing to subtle folding. Where exposed, the Lewis Shale is inclined 3∞–6∞, the Lance Formation 10∞–25∞, the China Butte Member 20∞–30∞ (south of Muddy Creek), and the Overland Member 3∞–10∞. The steeper dips in the Lance and Fort Union Formations are on the west-dipping limb of a monocline that extends south across the Dad arch and into the Blue Gap and Peach Orchard Flats quadrangles (see mapping by Honey and Hettinger, 2004; Hettinger and Honey, 2005).

Several extensional faults trend from the Cedars area (fig. 1) northeast to the south side of Doty Mountain. Faulting in that area is complex and some faults, in addition to those mapped, may be obscured by surficial cover. Faults dip north and northwest and displacement is down to the north and northwest. Reverse drag on the downthrown sides has tilted beds 4∞–39∞ southward toward the faults, indicating a possible listric origin. Anticlinal axes mapped along the flexures are associated with the reverse drag.

Thirty-five wells have been drilled for oil and gas in the Doty Mountain 7.5-minute quadrangle (fig. 4, table 2). Named fields include Baldy Butte, Creston, Cow Creek, and Doty Mountain. Producing strata and trapping conditions in the fields are as follows: (1) Baldy Butte–stratigraphic traps in the Upper Cretaceous Almond Formation (Specht, 1992) and some production from the Lewis Shale (Wyoming Oil and Gas Conservation Commission, 2005); (2) Creston–stratigraphic traps in the Upper Cretaceous Almond and Ericson Formations (Coalson, 1979); (3) Cow Creek–structural and (or) stratigraphic traps in the Cretaceous Mesaverde Group, and Morapos, Frontier, and Dakota Formations, and Jurassic Nugget Sandstone (Reinert, 1979); (4) Doty Mountain–gas from coal beds in the Upper Cretaceous Mesaverde Group (Wyoming Oil and Gas Conservation Commission, 2005).

ACKNOWLEDGMENTS

We thank Ven Barclay for discussions regarding stratigraphy in the eastern part of the Greater Green River Basin, and for providing mapping of some of the Quaternary deposits near the eastern boundary of the quadrangle. Christopher Potter provided insight regarding faulting in the vicinity of Doty Mountain. Steve Roberts and Art Clark drilled USGS coal-test holes DM-3, DM-4, DM-5, and DL-D1, and field assistance was provided by Judith Back and Robert Brown. Joseph East provided digital cartography for the geologic map. We thank the Anadarko Petroleum Company for granting permission to show our interpretations of holes drilled by their subsidiaries, the Rocky Mountain Energy Company and Union Pacific Corporation. We appreciate the comprehensive reviews by Margaret Ellis and Robert O'Sullivan, and the editorial reviews by William Keefer and Alessandro Donatich.

REFERENCES CITED

Coalson, E.B., 1979, Creston Unit III (Creston), in Oil and Gas Field Symposium Committee, eds., Wyoming oil and gas fields symposium, Greater Green River Basin: Wyoming Geological Association, p. 113.

Dames and Moore Company, 1979, Coal resource occurrence and coal development potential maps of the northwest quarter of the Doty Mountain 15-minute quadrangle, Carbon County, Wyoming: U.S. Geological Survey Open-File Report 79–1382, 38 p., 32 oversized sheets, scale 1:24,000.

Edson, G.M., 1979, Preliminary geologic map and coal sections of the Seaverson Reservoir quadrangle, Carbon County, Wyoming: U.S. Geological Survey Open-File Report 79–1577, scale 1:24,000.

Gill, J.R., Merewether, E.A., and Cobban, W.A., 1970, Stratigraphy and nomenclature of some Upper Cretaceous and lower Tertiary rocks in south-central Wyoming: U.S. Geological Survey Professional Paper 667, 53 p.

Hasiotis, S.T., and Honey, J.G., 2000, Paleohydrologic and stratigraphic significance of crayfish burrows in continental deposits–Examples from several Paleocene Laramide basins in the Rocky Mountains: Journal of Sedimentary Research, v. 70, no. 1, p. 127–139.

Henderson, D.K., 1962, Geology of the Doty Mountain–Dad area, Carbon County, Wyoming; emphasis on stratigraphy of uppermost Cretaceous rocks: Golden, Colo., Colorado School of Mines M.S. thesis, 162 p., 4 plates, scale 1:62,500.

Hettinger, R.D., and Brown, R., 1979, Geophysical and lithologic logs of 1977 coal drilling in the Fort Union

Formation, Carbon and Sweetwater Counties, Wyoming: U.S. Geological Survey Open-File Report 79–326, 81 p.
Hettinger, R.D., and Honey, J.G., 2005, Geologic map and coal stratigraphy of the Blue Gap quadrangle, eastern Washakie Basin, Carbon County, Wyoming: U.S. Geological Survey Scientific Investigations Map 2878, version 1.0, scale 1:24,000.
Hettinger, R.D., Honey, J.G., and Nichols, D.J., 1991, Chart showing correlations of Upper Cretaceous Fox Hills Sandstone and Lance Formation, and lower Tertiary Fort Union, Wasatch, and Green River Formations, from the eastern flank of the Washakie Basin to the southeastern part of the Great Divide Basin, Wyoming: U.S. Geological Survey Miscellaneous Investigations Series Map I–2151, 1 sheet.
Hettinger, R.D., and Kirschbaum, M.A., 1991, Chart showing correlations of some Upper Cretaceous and lower Tertiary rocks from the east flank of the Washakie Basin to the east flank of the Rock Springs uplift, Wyoming: U.S. Geological Survey Miscellaneous Investigations Series Map I–2152, 1 sheet.
Honey, J.G., and Hettinger, R.D., 1989a, Cross section showing correlations of Upper Cretaceous Fox Hills Sandstone and Lance Formation, and lower Tertiary Fort Union and Wasatch Formations, southeastern Washakie Basin, Wyoming, and eastern Sand Wash Basin, Colorado: U.S. Geological Survey Miscellaneous Investigations Series Map I–1964, 1 sheet.
Honey, J.G., and Hettinger, R.D., 1989b, Stratigraphic sections showing coal correlations within the lower coal zone of the Paleocene Fort Union Formation, Fillmore Ranch and Seaverson Reservoir quadrangles, Carbon County, Wyoming: U.S. Geological Survey Coal Investigations Map C–127, 2 sheets.
Honey, J.G., and Hettinger, R.D., 2004, Geologic map of the Peach Orchard Flat quadrangle, Carbon County, Wyoming, and descriptions of new stratigraphic units in the Upper Cretaceous Lance Formation and Paleocene Fort Union Formation, eastern Greater Green River Basin, Wyoming-Colorado: U.S. Geological Survey Scientific Investigations Map 2835, version 1.1, scale 1:24,000.
Love, J.D., and Christiansen, A.C., 1985, Geologic map of Wyoming: U.S. Geological Survey and the Geological Survey of Wyoming, scale 1:500,000.
Luft, S.J., 1985, Generalized geologic map showing distribution and basal configuration of the Browns Park Formation and Bishop Conglomerate in northwestern Colorado, northeastern Utah, and southern Wyoming: U.S. Geological

Survey Miscellaneous Field Studies Map MF–1821, scale 1:250,000.
Nichols, D.J., and Ott, H.L., 1978, Biostratigraphy and evolution of the Momipites-Caryapollenites lineage in the early Tertiary of the Wind River Basin, Wyoming: Palynology, v. 2, p. 93–112.
Perman, C.R., 1990, Depositional history of the Maastrichtian Lewis Shale in south-central Wyoming–Deltaic and interdeltaic, marginal marine, and trough deep-water marine environments: American Association of Petroleum Geologists Bulletin, v. 74, no. 11, p. 1695–1717.
Pipiringos, G.N., 1961, Uranium-bearing coal in the central part of the Great Divide Basin, Sweetwater County, Wyoming: U.S. Geological Survey Bulletin 1099–A, 104 p., scale 1:62,500.
Pyles, D.R., and Slatt, R.M., 2000, A high-frequency sequence stratigraphic framework for shallow through deep-water deposits of the Lewis Shale and Fox Hills Sandstone, Great Divide and Washakie Basins, Wyoming, in Weimer, P., and others, eds., Deep-water reservoirs of the world: Gulf Coast Section Society of Economic Paleontologists and Mineralogists Foundation, 20th Annual Bob F. Perkins Research Conference, p. 836–861.
Reinert, S.L., 1979, Cow Creek, in Oil and Gas Field Symposium Committee, eds., Wyoming oil and gas fields symposium, Greater Green River Basin: Wyoming Geological Association, p. 106–108.
Sanders, R.B., 1975, Geologic map and coal resources of the Creston Junction quadrangle, Carbon and Sweetwater Counties, Wyoming: U.S. Geological Survey Coal Investigations Map C–73, scale 1:24,000.
Specht, R.G., 1992, Baldy Butte, in Oil and Gas Field Symposium Committee, eds., Wyoming oil and gas fields symposium, Greater Green River Basin and Overthrust Belt: Wyoming Geological Association, p. 28–29.
Swain, B.W., 1957, Fort Union Formation, west flank of Sierra Madre, Carbon County, Wyoming: Laramie, Wyo., University of Wyoming M.S. thesis, 132 p.
Witton, E.M., 1999, Outcrop and subsurface characterization of the Lewis Shale, Carbon County, Wyoming: Golden, Colo., Colorado School of Mines M.S. thesis, 214 p.
Wyoming Oil and Gas Conservation Commission, 2005, On-line database at http://wogcc.state.wy.us/ [accessed during 2005].

This map was produced on request, directly from digital files, on an electronic plotter
For sale by U.S. Geological Survey Information Services
Box 25286, Federal Center, Denver, CO 80225
1-888-ASK-USGS
ArcInfo coverages and a PDF for this map are available at
http://pubs.usgs.gov