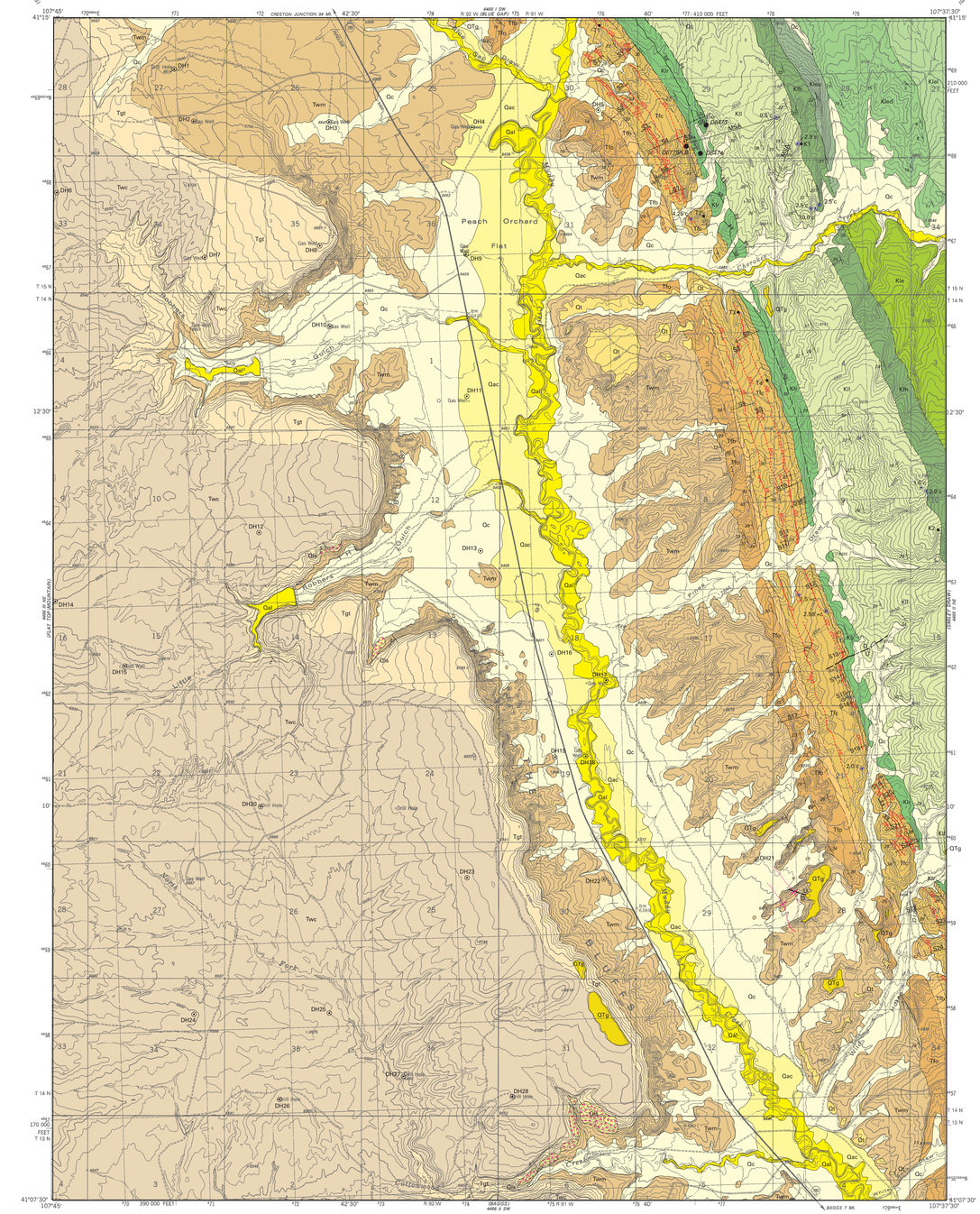
U.S. DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

SCIENTIFIC INVESTIGATIONS MAP 2835
SHEET 1 OF 2
Version 1.1
Pamphlet accompanies map



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

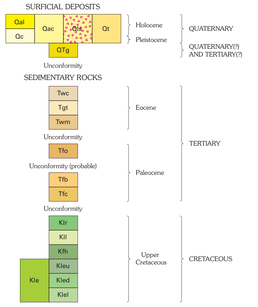
APPROXIMATE MEAN DECLINATION, 2003

SCALE 1:24 000
1 MILE
1 KILOMETER
CONTOUR INTERVAL 20 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929

WYOMING
QUADRANGLE LOCATION

Geology mapped by R.D. Hettinger and J.G. Honey, 1980 and 1981
Geologic linework digitized by Anna K. Scarbrough and Joseph A. East
Edited by Alessandro J. Donatich, Central Publications Group

CORRELATION OF MAP UNITS



DESCRIPTION OF MAP UNITS

Qal **Alluvium (Holocene)**—Clay, silt, sand, and gravel deposited along courses of active streams

Qc **Colluvium (Holocene and Pleistocene)**—Undivided alluvial fan, slope wash, and slump deposits

Qac **Alluvium and colluvium, undivided (Holocene and Pleistocene)**—Alluvial and colluvial deposits along course of Muddy Creek; likely consists mostly of alluvium

Landslide deposits (Holocene and Pleistocene)—Mixed debris of soil and bedrock, mainly in areas underlain by the Green River Formation

Qt **Terrace deposits (Holocene and Pleistocene)**—Silt, sand, and gravel; maximum cobble size 0.66 ft. Cobbles consist of medium-grained sandstone containing *Gonlobasis*; tan or gray, fine-grained quartzite; medium-gray limestone; light-gray chert; ironstone; petrified wood; white quartz; gray or pink granitic rocks; basalt; and dark-gray schist. Also contains some locally derived dusky-purple-gray, upper fine- to lower medium-grained sandstone blocks as much as 4 ft long. As much as 30 ft thick

QTg **Gravel deposits (Quaternary? and Tertiary?)**—Higher deposits of uncertain origin, containing pebbles and cobbles as much as 0.5 ft in diameter of dark-gray, brown, and black chert; brown, fine- to medium-grained sandstone; red and white quartzite; limestone; cobble; petrified wood; light-gray to white quartz; and gray, porphyritic volcanic and granitic rocks; all in a sand and silt matrix. As much as 17 ft thick

Twc **Wasatch Formation (Eocene)**

Cathedral Bluffs Tongue—A 71-ft partial section measured 1.2 mi south of Peach Orchard Flat quadrangle in northern part of Baggs 7.5-minute quadrangle consists of interbedded reddish-brown and lavender mudstones and greenish-gray, white-weathering, very fine grained to fine-grained sandstones; sandstones are locally calcareous and silty (Honey, 1988). Other lithologies present in boundary area of the two quadrangles include tan, locally crossbedded sandstones, gray shales, and mudstones (Roehler, 1988). Only the lowest few hundred feet of the Cathedral Bluffs Tongue is present in west half of Peach Orchard Flat quadrangle; typically forms broad, gentle slopes with intermittent, short exposures. West of Peach Orchard Flat quadrangle, in sec. 14, T. 14 N., R. 93 W., the Cathedral Bluffs Tongue is 1,360 ft thick in True Oil Company, Mattie No. 1 well

Twm **Main body**—Predominantly variegated mudstone; some interbedded light-gray and grayish-brown, fine-grained sandstone and lenticular, coarse-grained, conglomeratic sandstone. Base of main body is marked by medium- to coarse-grained sandstone, generally containing lenses and stringers of conglomeratic sandstone with pebbles as much as 2.5 in. in diameter. Pebbles consist mainly of light- to dark-gray chert; pink chert with Paleozoic fossils; gray, white, and pink quartzite and quartz; and rare pebbles of limestone, pink porphyritic igneous rock, and petrified wood. Top of conglomeratic sandstone is commonly cemented and stained reddish brown with iron oxide, forming a resistant ledge. Along strike, conglomeratic sandstone varies from being reddish brown and hard to being very light gray and more friable. This basal sandstone varies in thickness in outcrop, from about 1 ft to more than 11 ft in Peach Orchard Flat quadrangle. Thicker basal sandstones are composite units consisting of stacked channels. North of Peach Orchard Flat quadrangle, basal conglomeratic sandstone locally is as much as 30 ft thick. Contact with the underlying Fort Union Formation is sharp and undulating and represents an unconformity.

Lowest ±100 ft of main body above basal sandstone is generally well exposed and consists of varicolored (red, maroon, green, yellow) mudstone, siltstone, and claystone interbedded with very light gray and grayish-brown, fine-grained sandstones and some lenticular, coarse-grained, conglomeratic sandstone (Hettinger and others, 1991). In hand specimen, fine-grained sandstones are predominantly quartz with lesser feldspar, and commonly have a sugary texture.

Most of remainder of main body is typically covered by alluvium and mixed alluvium/colluvium deposited in valley of Muddy Creek. Uppermost 305 ft, however, is well exposed and consists of interbedded sandstone, siltstone, and mudstone. Sandstone is light to yellowish gray, silty or clean, and mainly fine to medium grained; coarse-grained layers are rare. Crossbedding and ripple lamination are rare. Siltstone generally is light to yellowish gray, sandy, and usually thinly interbedded with mudstone or sandstone; although an 11-ft bed was encountered. Mudstones form red- and purple-mottled, popcorn-weathering slopes, locally with small, reddish-purple iron-oxide concretions scattered across slopes. Mudstone forms beds as much as 19 ft thick, or is thinly interbedded with other lithologies. In drill hole DH 28, main body is about 2,100 ft thick

Green River Formation (Eocene)

Tgt **Tipton Tongue**—Descriptions and interpretations of Tipton lithofacies in southern part of Peach Orchard Flat quadrangle have been published by Roehler (1988) and Hanley (1988); their studies showed the Tipton Tongue includes gray or tan sandstone, brown and gray oil shale, and minor gray mudstone, siltstone, and shale. Sandstone is fine- to coarse-grained and commonly crossbedded, and locally contains chert pebbles and concentrations of fossil nonmarine mollusks. Less than 1 mi north of Peach Orchard Flat quadrangle, in sec. 22, T. 15 N., R. 92 W., in Blue Gap 7.5-minute quadrangle, the Tipton Tongue is predominantly fine- to coarse-grained sandstone with a basal 9-ft-thick paper shale. Individual sandstones coarsen upward, are mainly horizontally stratified, and contain mollusk shell fragments in their lower parts (Hettinger and others, 1991). The Tipton Tongue ranges in thickness from 20 to 120 ft in Peach Orchard Flat quadrangle

Fort Union Formation (Paleocene)

Tfo **Overland Member**—Newly named in this report. Mainly light- to medium-gray sandstones, mudstones, and siltstones, and minor reddish ironstone. In sec. 21, T. 14 N., R. 91 W., base of unit is marked by a light-gray, fine- to medium-grained sandstone about 5 ft thick, containing lenses of very coarse grained quartz, feldspar, and chert, and isolated chert pebbles as much as 1 in. in diameter. Thickness of this basal sandstone is variable. In sec. 34, T. 14 N., R. 91 W. and sec. 3, T. 13 N., R. 91 W., less than 500 ft east of Peach Orchard Flat quadrangle, basal sandstone consists of about 60 ft of stacked, conglomeratic channel sandstones, forming the lower part of a probable valley-fill succession. Above the basal sandstone, sandstones are predominantly fine grained and silty, generally massive, and in places bioturbated; trough crossbedding is preserved in only a few fine- to coarse-grained sandstones. Ripple lamination is present in a few fine-grained, calcareous sandstones. Lower contacts of sandstones are commonly irregular and slightly erosional. Silty sandstone is the most common lithology in the Overland Member, in places composing roughly 40 percent of unit. Other sandstone is thinly interlayered with siltstone and mudstone; interbedded sandstone, mudstone, and siltstone constitute about 31 percent of this member. Mudstone and siltstone are light to medium gray and sandy, and compose about 25 percent; where thinly interbedded with sandstone they may contain scattered plant fragments, rootlets, and carbonaceous or clayey streaks. Near the contact with the overlying Wasatch Formation, mudstones are locally red and purple mottled. Ironstones are sandy and pisolitic, and are in tabular layers as much as 2 ft thick. Crayfish burrows are present locally in all lithologies, and are iron-oxide stained in some of the massive sandstones, mudstones, and siltstones. In some cases, crayfish burrows project down into sandstone or mudrock from an overlying ironstone, and in one case form a cylindrical mass of intertwined burrows nearly 6 ft high (Hasiotis and Honey, 2000, their fig. 6A). In sec. 21, T. 14 N., R. 91 W., the Overland Member is 425 ft thick in outcrop

Tfb **Blue Gap Member**—Newly named in this report. Poorly exposed in Peach Orchard Flat quadrangle. The type area of the Blue Gap Member is located about 1.5 mi southeast of southeast corner of Peach Orchard Flat quadrangle, in NE1/4 sec. 15 and SE1/4 sec. 10, T. 13 N., R. 91 W., Dixon 7.5-minute quadrangle. There, excellent exposures of part of unit consist mainly of claystone and mudstone; siltstone and sandstone are less common, and ironstone is rare. Mudstone is olive to brownish gray, silty in part, rarely sandy, and slightly carbonaceous and noncalcareous, and weathers blocky or fissile. Rootlets and horizontal plant fragments, some woody or carbonized, are common; density of rootlets and plant fragments in places increases upwards in individual beds. Leaf fossils are more rare, and appear to be most common in thinly interbedded claystone/siltstone/sandstone units; resin blebs were found in one place. Siltstones are olive to brownish gray, sandy or clayey, and commonly contain rootlets and plant fragments; some carbonized. Sandstones are light gray to yellowish brown, very fine grained to fine grained, rarely medium grained, and in beds from less than 1 ft to as much as 5 ft thick. Some sandstones show trough crossbedding and have sharp, slightly erosional bases containing claystone clasts; these sandstones fine upward to siltstone and claystone that may be rooted. A few coarsening-upward cycles, from claystone to very fine grained sandstone, are present. Ironstones are purple to blackish red, concretionary, and range from 6 in. to 2 ft in thickness. Base of the Blue Gap Member is recognized by appearance of first thick mudstones and claystones about 100 ft above highest coal-bearing beds in the underlying China Butte Member (new name). Just north of Peach Orchard Flat quadrangle, in sec. 24, T. 15 N., R. 92 W., Blue Gap 7.5-minute quadrangle, the Blue Gap Member is 160 ft thick on outcrop (Hettinger and others, 1991, their measured section D)

Tfc **China Butte Member**—Newly named in this report. Interbedded sandstone, siltstone, mudstone, carbonaceous shale, and coal that typically form stacked, fining-upward cycles. Sandstones at bases of fining-upward units are generally fine to medium grained and commonly are thick compared to other lithologies (as much as 212 ft in measured section S4, and thickest in northern part of map area); observations in nearby areas show that thicker sandstone bodies are multistoried. Fining-upward cycles are commonly capped by coal beds, which in turn are overlain by a few feet of mudrock, or directly by basal sandstone of next cycle. Thickest coal beds measured at surface range from about 10 to 12 ft, including thin partings; subsurface coals show similar thicknesses.

The basal unit of the China Butte Member (shown by pattern on geologic map, sheet 1) is a thick sandstone that is generally poorly exposed in Peach Orchard Flat quadrangle, except for uppermost beds, which locally consist of very light gray, trough crossbedded, upper fine grained to upper very coarse grained sandstone; coarser grains include gray and black chert and quartz. A persistent 2- to 4-ft-thick conglomerate and conglomeratic sandstone unit marks the base of this sandstone, and contains abundant pebbles, as much as 2 in. in diameter, of gray and black chert, lesser amounts of white and pink quartzite and quartz, and minor porphyritic felsic igneous rock, in a coarse-grained, iron oxide-cemented sandstone matrix. Conglomerate commonly forms a resistant, reddish-brown ledge, and overlies an unconformity between Cretaceous and Tertiary strata (Honey and Hettinger, 1989b; Hettinger and others, 1991). Outcrop-measured thicknesses of this basal sandstone in Peach Orchard Flat quadrangle range from 62 to 142 ft. In secs. 29 and 32, T. 15 N., R. 91 W. (measured sections S4, S5, and S6), the China Butte Member is about 885 ft thick. Detailed descriptions of measured sections in the China Butte Member are given in Honey (1984).

Coal zones in Peach Orchard Flat quadrangle were originally named and mapped in Seaverson Reservoir and Fillmore Ranch quadrangles (fig. 1) by Edson (1979) and Honey and Hettinger (1989a). The following names were applied, based on detailed mapping and correlation studies, to five coal-bearing zones in Peach Orchard Flat quadrangle by Honey and Robinson Roberts (1989):

FR, Fillmore Ranch coal zone;
Mcu, upper Muddy Creek coal zone;
MCl, lower Muddy Creek coal zone;
OD, Olson Draw coal zone equivalent;
RR, Red Rim coal zone

Klr **Lance Formation (Upper Cretaceous)**

Red Rim Member—Newly named in this report. Basal 197 ft of the Red Rim Member of the Lance Formation is concealed in Peach Orchard Flat quadrangle, forming a valley floor; rare exposures and sandy soil, however, indicate that this interval is predominantly sandstone. Remainder of the Red Rim Member is predominantly medium- and coarse-grained sandstone containing chert pebbles, with rare siltstone and claystone mainly in fining-upward units. Very fine grained and fine-grained sandstones are much less common, and are in thin, ripple-laminated units either interbedded with siltstone and claystone, or present in the upper parts of some sandstone bodies. Top 100 ft of member consists of superposed medium- to coarse-grained, trough crossbedded sandstone bodies as much as 23 ft thick, that show strong cross-cutting relations. Bases of individual sandstones commonly have lags containing siltstone and claystone clasts as much as 6 in. in diameter; these pebbles are also scattered throughout sandstones, commonly along foresets. These coarse-grained basal lags are overlain by medium- to coarse-grained, trough crossbedded sandstone that in a few cases is overlain by fine- to medium-grained, ripple-laminated sandstone. Chert pebbles are abundant, especially in upper 100 ft of the Red Rim Member, and are generally observed in pockets, along forest beds, or as basal lags in association with siltstone and claystone pebbles. Although chert grains are in some sandstones lower in the Lance, the lowest strata with chert pebbles in post-Lewis Shale rocks in this area appear to be in the Red Rim Member. In Peach Orchard Flat quadrangle, the Red Rim Member is sharply overlain by basal conglomerate of the Fort Union Formation. Outcrop-measured thickness of the Red Rim Member in Peach Orchard Flat quadrangle is 380 ft

Kll **Lower member**—An overall coarsening-upward succession; mudrock lithologies dominate basal 1,150 ft of member, and sandstone is more abundant in upper 525 ft. Total thickness is about 1,675 ft.

Upper 525 ft of lower member of the Lance Formation consists mainly of very fine grained to medium-grained sandstone, with less common mudstone, siltstone, claystone, and carbonaceous shales, all commonly composing fining-upward cycles. Sandstones vary in thickness to a maximum of about 37 ft; thicker units are multistoried, pinch out laterally, and commonly have sharp basal contacts with underlying fining-upward cycles. Crossbedding and ripple lamination are locally preserved in sandstones; stringers or thin interbeds of carbonaceous shale and mudstone, and mudstone clasts, are common in some sandstones. Silty or sandy ironstone is also present as thin layers or small concretions as much as 4 in. across. Top 60 ft consists of interbedded thin sandstones, mudstones, siltstones, and claystones.

Basal 1,150 ft of lower member consists of interbedded gray to brown claystone, clay shale, carbonaceous shale, siltstone, and mudstone; light-gray to yellowish-gray sandstone; and black coal. Scattered plant fragments are common in finer grained lithologies, and leaf impressions were observed in a few sandstones. Basal 350 ft is dominated by carbonaceous shale, with lesser amounts of coal and sandstone. Several coal beds, the thickest one as much as 6.0 ft thick, are in a zone from 25 to 45 ft above base of formation; a 2-ft-thick coal is 85 ft above base of formation, and additional coal beds, all less than 1 ft thick, are rare above this level. Sandstones are as much as 20 ft thick, well sorted, quartzitic, and commonly calcareous and ripple laminated; a few thicker beds are trough crossbedded. Sandstones are almost exclusively very fine grained in lower 250 ft of unit, with generally thicker, fine-grained sandstones increasing in abundance higher up; sandstones in upper 185 ft are very fine grained to medium grained. Only the lower 535 ft and the upper 185 ft of basal part of lower member are exposed in Peach Orchard Flat quadrangle; intervening 430 ft interval is completely covered, but nearby geophysical logs indicate similar interbedded lithologies of mudrock and very fine grained to fine-grained sandstone

Kfh **Fox Hills Sandstone (Upper Cretaceous)**—Yellowish-orange to moderate-yellowish-brown, very fine grained to fine-grained, locally calcareous sandstone, containing some interbedded medium-gray to olive-brown, silty to sandy shale. Sandstone is thin to massive bedded, locally contains *Ophiomorpha*, and in part concretionary, with concretions ranging from as small as 4 in. in diameter to as much as 4 ft thick and 30 ft in diameter. Shale is locally slightly calcareous, and forms beds as much as 40 ft thick. Basal contact of the Fox Hills is gradational, and top contact is sharp and locally intertongues with the Lance Formation. The Fox Hills is nearshore marine and marginal marine in origin. From 150 to 200 ft thick in outcrop (in part from Gill, Merewether, and Cobban, 1970)

Kle **Lewis Shale, undivided (Upper Cretaceous)**—Gray marine shale; weathers grayish yellow. Divisible into two predominantly shale parts separated by the Dad Sandstone Member. Upper part of the Lewis Shale and Dad Sandstone Member were mapped separately north of Cherokee Creek; the Lewis Shale was mapped as undivided (**Kle**) south of Cherokee Creek, due to poor exposure. About 850 ft of undivided Lewis Shale exposed in quadrangle

Kleu **Upper part**—Contains more sandstone and siltstone than lower part of Lewis Shale; sandstone beds are as much as 0.4 ft thick. Upper part of the Lewis Shale is 330 ft thick in outcrop (Gill and others, 1970)

Kled **Dad Sandstone Member**—Pale-yellowish-gray, very fine grained sandstone, interbedded with olive-gray sandy shale that weathers light to yellowish gray and may contain some thin fine-grained sandstone beds. Sandstone is locally concretionary; concretions are spherical and as much as 1.5 ft in diameter, or are larger concretionary masses as much as 8 ft thick and 20 ft in diameter. The Dad Sandstone Member is 585 ft thick in outcrop (Gill and others, 1970) and represents marine turbidites (Perman, 1990; Witton 1999). Principal reference section of the Dad Sandstone Member is located in this quadrangle in secs. 27 and 28, T. 15 N., R. 91 W.

Klel **Lower part**—Dark-gray marine shale. Only the top 250 ft is exposed in quadrangle

Contact—Approximately located. Dashed where covered or inferred

Coal bed or zone—Dashed where approximately located or inferred. Name of coal zone abbreviated in capital letters; unnamed or uncorrelated coal bed designated by *c*. Abbreviations: *RR*, Red Rim; *OD*, Olson Draw equivalent; *MCl*, lower Muddy Creek; *MCu*, upper Muddy Creek; *FR*, Fillmore Ranch

Clinker—Burned coal bed and rocks baked by burning of coal bed

Sandstone marker bed—Approximately located

Fault—Dashed where approximately located; dotted where concealed. U, upthrown side; D, downthrown side

Anticline—Showing crestline. Approximately located; dotted where concealed

Syncline—Showing crestline. Approximately located; dotted where concealed

Strike and dip of beds

Measured on outcrop

Measured photogrammetrically on a computerized PG-2 plotter

USGS palynomorph locality

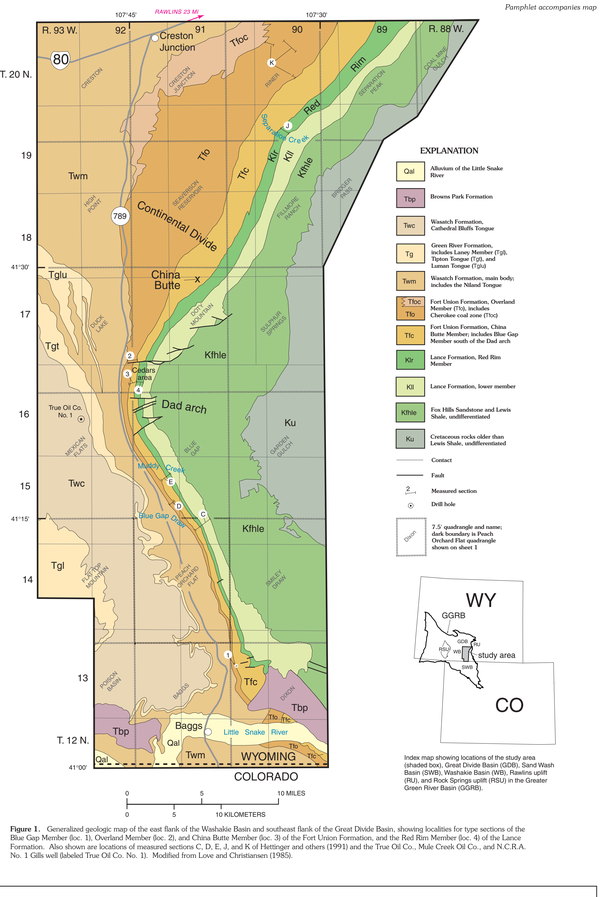
Oil and gas well—Showing number on map and in table 1

Isolated coal measurement in feet

Short coal measured section—Showing number on map and in table 2. K, Cretaceous; T, Tertiary

Line of measured section—Showing number on map, and in stratigraphic section on sheet 2. MSA, measured section of Lance Formation

Basal unit of China Butte Member of Fort Union Formation



Index map showing locations of the study area (shaded box), Great Divide Basin (GDB), Sand Wash Basin (SWB), Washakie Basin (WB), Rawlins uplift (RU), and Rock Springs uplift (RSU) in the Greater Green River Basin (GGRB).

Figure 1. Generalized geologic map of the east flank of the Washakie Basin and southeast flank of the Great Divide Basin, showing localities for type sections of the Blue Gap Member (loc. 1), Overland Member (loc. 2), and China Butte Member (loc. 3) of the Fort Union Formation, and the Red Rim Member (loc. 4) of the Lance Formation. Also shown are locations of measured sections C, D, E, J, and K of Hettinger and others (1991) and the True Oil Co., Mule Creek Oil Co., and N.C.R.A. No. 1 Gills well (labeled True Oil Co. No. 1). Modified from Love and Christiansen (1985).

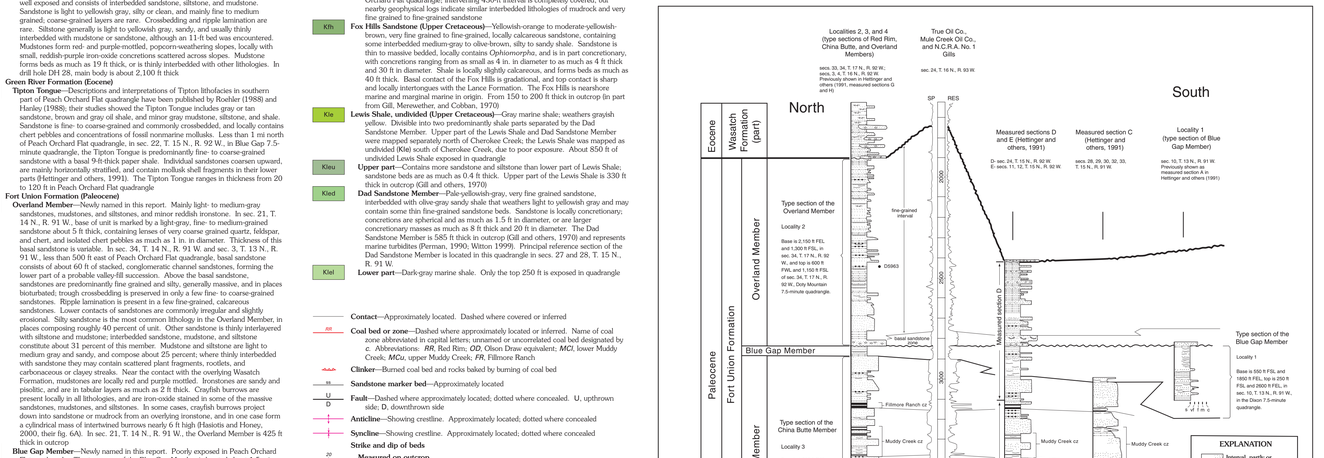


Figure 2. Stratigraphic sections and correlations of the Lance and Fort Union Formations along the east flank of the Washakie Basin. Shown are the type sections of the Red Rim Member of the Lance Formation (loc. 4), China Butte and Overland Members of the Fort Union Formation (locs. 2 and 3), and Blue Gap Member of the Fort Union Formation (loc. 1). Also shown are measured sections C, D, and E of Hettinger and others (1991). Locations are shown in figure 1.

Table 1. Drill holes shown on geologic map

[For depths to selected stratigraphic horizons, see Honey and Robinson Roberts (1989)]

Drill hole designation[1]	Company name	Well name	Location Sec.	T. N.	R. W.
DH1	Hamilton Brothers	No. 1 Federal	27	15	92
DH2	Sinclair Oil	No. 1-27 Hamilton Federal	27	15	92
DH3	---------do----------	No. 26-1 Hamilton Federal	26	15	92
DH4	---------do----------	GAO Federal 25-1	25	15	92
DH5	Kenai Oil	Federal 1-30	30	15	91
DH6	Snyder Oil	CIGE Federal No. 1-33	33	15	92
DH7	Sinclair Oil	Hamilton Federal 34-1	34	15	92
DH8	---------do----------	Hamilton Federal 35-1	35	15	92
DH9	---------do----------	Hamilton State 36-1	36	15	92
DH10	---------do----------	Grynberg Federal 2-1	2	14	92
DH11	Trigg Drilling	M.W. Federal 1-1	1	14	92
DH12	Snyder Oil	Puckett Federal 1-11	11	14	92
DH13	True Oil & Mule Creek Oil	No. 44-12 Mandel	12	14	92
DH14	Snyder Oil	Sun State 1-16	16	14	92
DH15	Getty Oil	SW Robbers Gulch A	15	14	92
DH16	Hadson Ohio Oil	Federal 1-18	18	14	91
DH17	True Oil	Hoc-State No.1	18	14	91
DH18	Trigg Drilling	Battle Mountain 1-19	19	14	91
DH19	True Oil	No. 2 Craig	19	14	91
DH20	Getty Oil	SW Robbers Gulch 11-23	23	14	92
DH21	True Oil	Vaughn A	29	14	91
DH22	Snyder Oil	Sun Federal 1-30	30	14	91
DH23	---------do----------	Sun State 1A-25-14-92	25	14	92
DH24	---------do----------	Sun Federal 1-34	34	14	92
DH25	---------do----------	Beverly Federal 1-35	35	14	92
DH26	Burton-Hawks Exploration	No. 1 Rutter Federal	35	14	92
DH27	Skelly Oil	Streckfus Draw No. 1	36	14	92
DH28	True Oil	Robbers Gulch No. 1	31	14	91

[1]Same numbering system as in Honey and Robinson Roberts (1989).

Table 2. Isolated coal measured sections shown on geologic map

Designation on map	Location Sec.	T. N.	R. W.	Formation	Coal (c) and parting (p) thicknesses in feet, listed from top to bottom
K1	28	15	91	Kll	0.67c, 2.0p, 1.17c, 0.25p, 4.5c, 1.58p, 2.9c
K2	10	14	91	Kll	9.38c, 1.33p, 2.13c
T1	30	15	91	Tfc	2.33c, 1.17p, 2.46c; see measured section 1 (Honey, 1984)
T2	32	15	91	Tfc	4.17c, 0.67p, 3.58c
T3	5	14	91	Tfc	0.25c, 0.33p, 1.83c, 1.33p, 2.67c; see measured section 8 (Honey, 1984).
T4	5	14	91	Tfc	2.75c; see measured section 10 (Honey, 1984)
T5	16	14	91	Tfc	See measured section 15 (Honey, 1984)

Table 3. Cross reference between measured sections shown on geologic map and measured sections described in Honey (1984)

Designation on geologic map[1]	Designation in Honey (1984)
S1	Section 2
S2	Section 3
S3	Section 4
S4	Section 5
S5	none
S6	Section 6
S7	Section 7
S8	Section 9
S9	Section 11
S10	Section 12
S11	Section 13
S12	Section 14
S13	Section 16
S14	Section 17
S15	Section 18
S16	Section 19
S17	none
S18	Section 20
S19	Section 21
S20	Section 22
S21	Section 23
S22	Section 24
S23	Section 25 and 26
S24	Section 27 (covered interval in section 27 is 276 ft rather than 242 ft as stated in Honey, 1984).
T1	Section 1
T2	none
T3	Section 8
T4	Section 10
T5	Section 15

[1]Same numbering system used for S1–S24 in Honey and Robinson Roberts (1989).

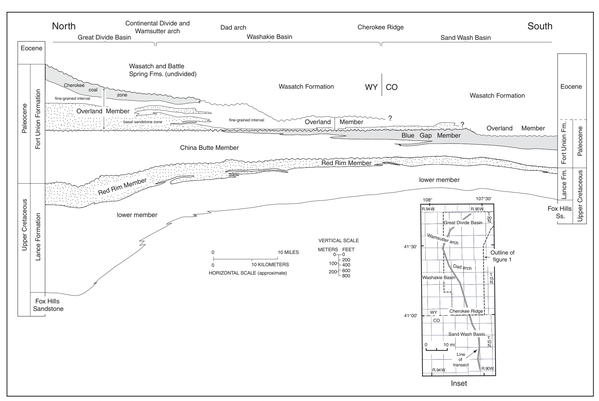


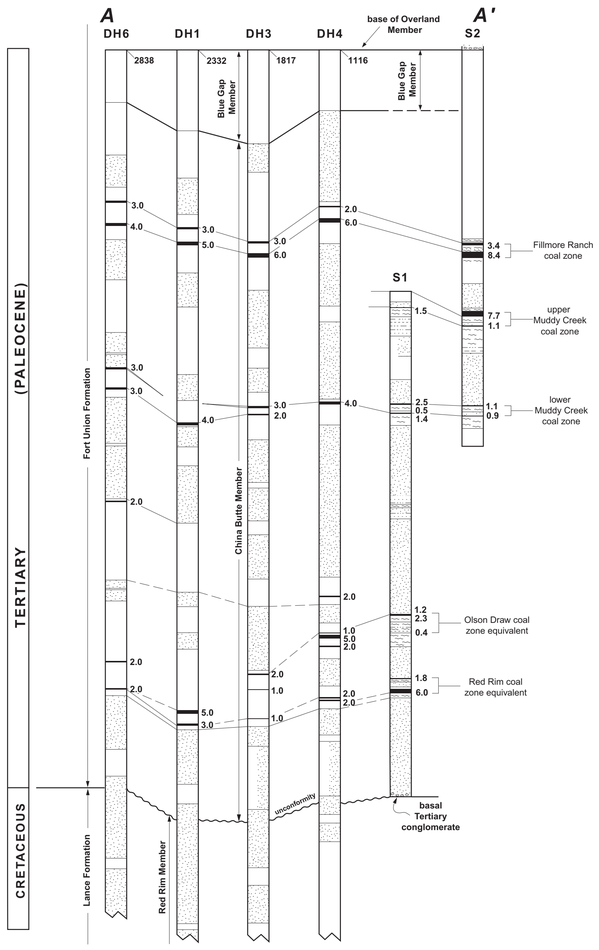
Figure 3. Chart showing aerial distribution of members in the Lance and Fort Union Formations along the east flanks of the Sand Wash and Washakie Basins in Colorado and Wyoming, and the southeast flank of the Great Divide Basin in Wyoming, a distance of about 80 mi. The distribution of strata was determined from outcrop and subsurface studies reported in Hettinger and others (1991) and Honey and Hettinger (1989). The basal Wasatch Formation contact as mapped in Wyoming was not extended into Colorado due a lack of stratigraphic control resulting from poor surface exposures. Location of transect is shown in inset. Modified from Hettinger and others (1991) and Honey and Hettinger (1989).

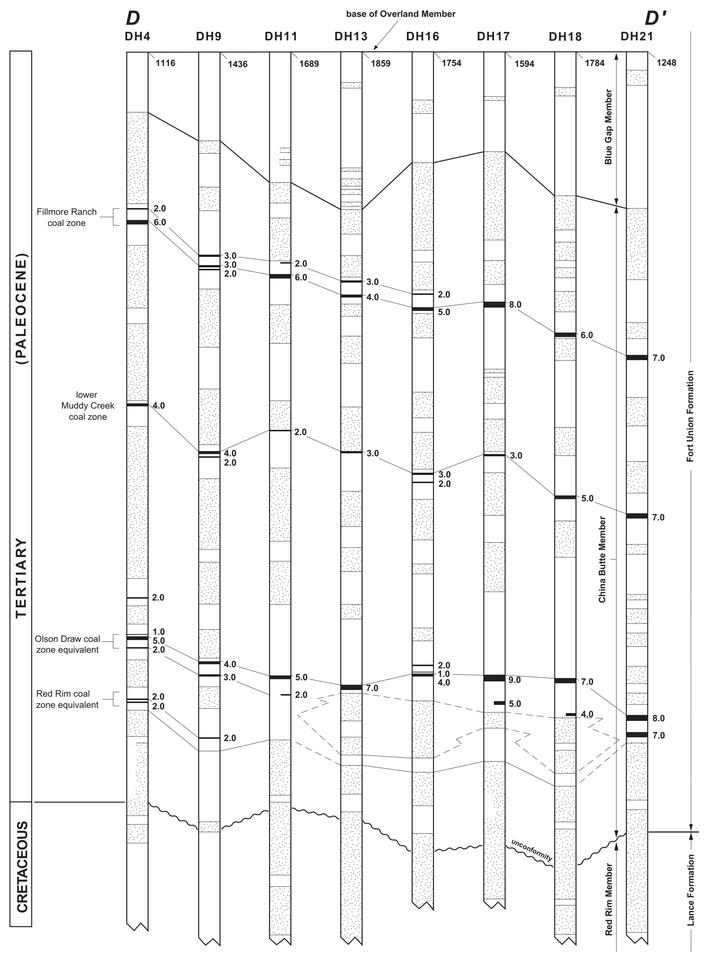
GEOLOGIC MAP OF THE PEACH ORCHARD FLAT QUADRANGLE, CARBON COUNTY, WYOMING, AND DESCRIPTIONS OF NEW STRATIGRAPHIC UNITS IN THE UPPER CRETACEOUS LANCE FORMATION AND PALEOCENE FORT UNION FORMATION, EASTERN GREATER GREEN RIVER BASIN, WYOMING-COLORADO

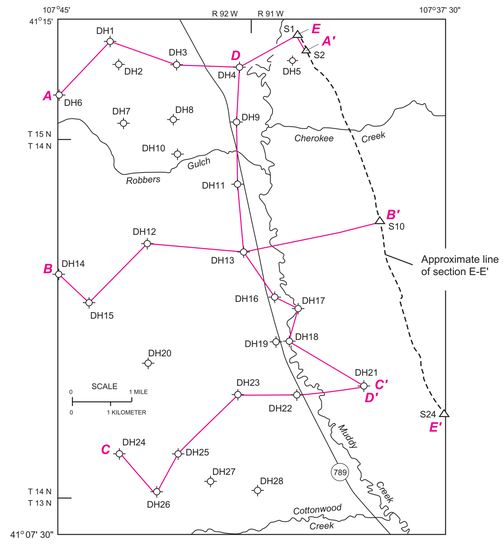
By
J.G. Honey and R.D. Hettinger

2004

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







Index map of Peach Orchard Flat quadrangle showing locations of cross sections, drill holes (◇), and selected measured sections shown on geologic map (△). Drill holes are identified in table 1.

Note: To convert measurements from feet to meters, multiply values in feet by 0.305

VERTICAL SCALE*
METERS 0 — 0 FEET
25 — 100
50 — 200
50
*No horizontal scale intended

EXPLANATION

Lithology

- Covered interval in measured section, or interval in drill hole consisting of undetermined lithology, mudrock, or thinly interbedded lithologies
- Conglomerate
- Sandstone
- Sandstone with pebbles or lenses of conglomerate
- Sandstone, thin bed
- Probable sandstone—Insufficient log resolution in drill hole or insufficient exposure in measured section
- Siltstone
- Mudstone
- Variegated mudstone
- Claystone
- Carbonaceous claystone or shale
- 8.0 Coal-Showing thickness in feet
- 4.5 1.0p 3.0 Coal with parting—Showing thicknesses of coal and parting (p) in feet
- 2.0 Probable coal—Showing thickness in feet. Insufficient log resolution to positively identify coal
- Clinker

Drill hole

DH26 ← Drill hole number—Shown also on geologic map and in table 1
3168 ← Reference depth in feet
Bottom of drill hole not shown

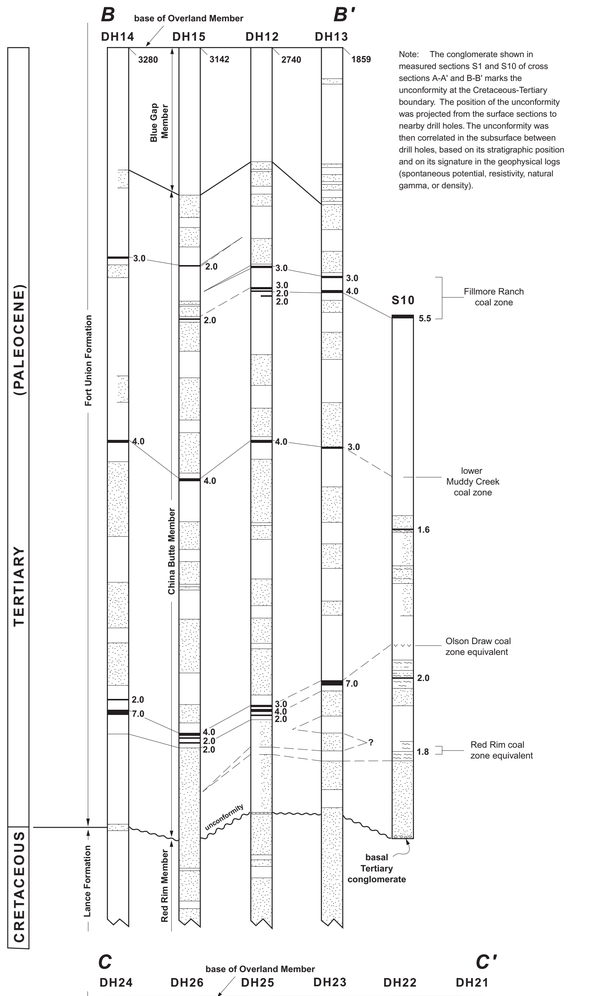
Measured section

S24 ← Measured section number—Shown also on geologic map

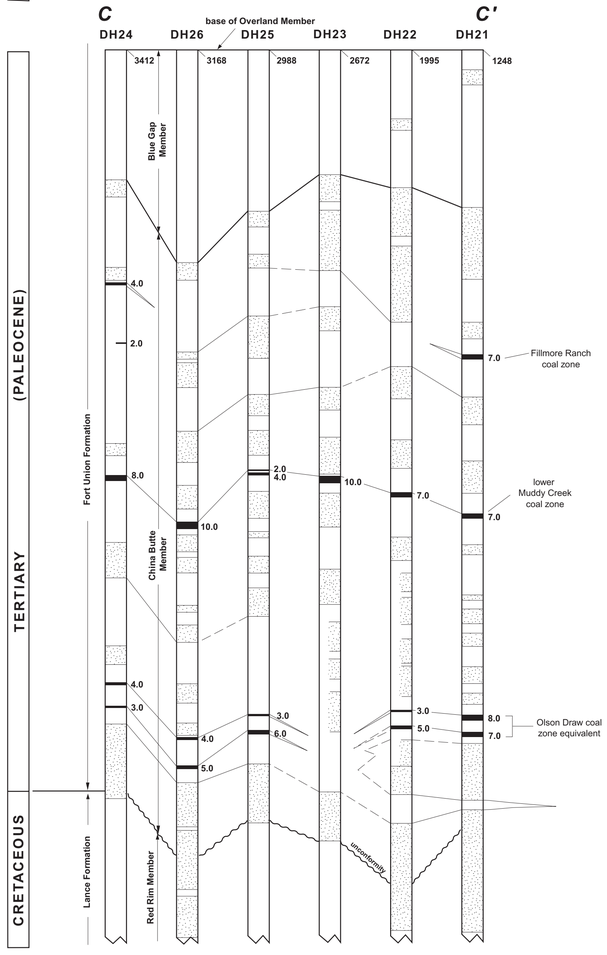
Correlations

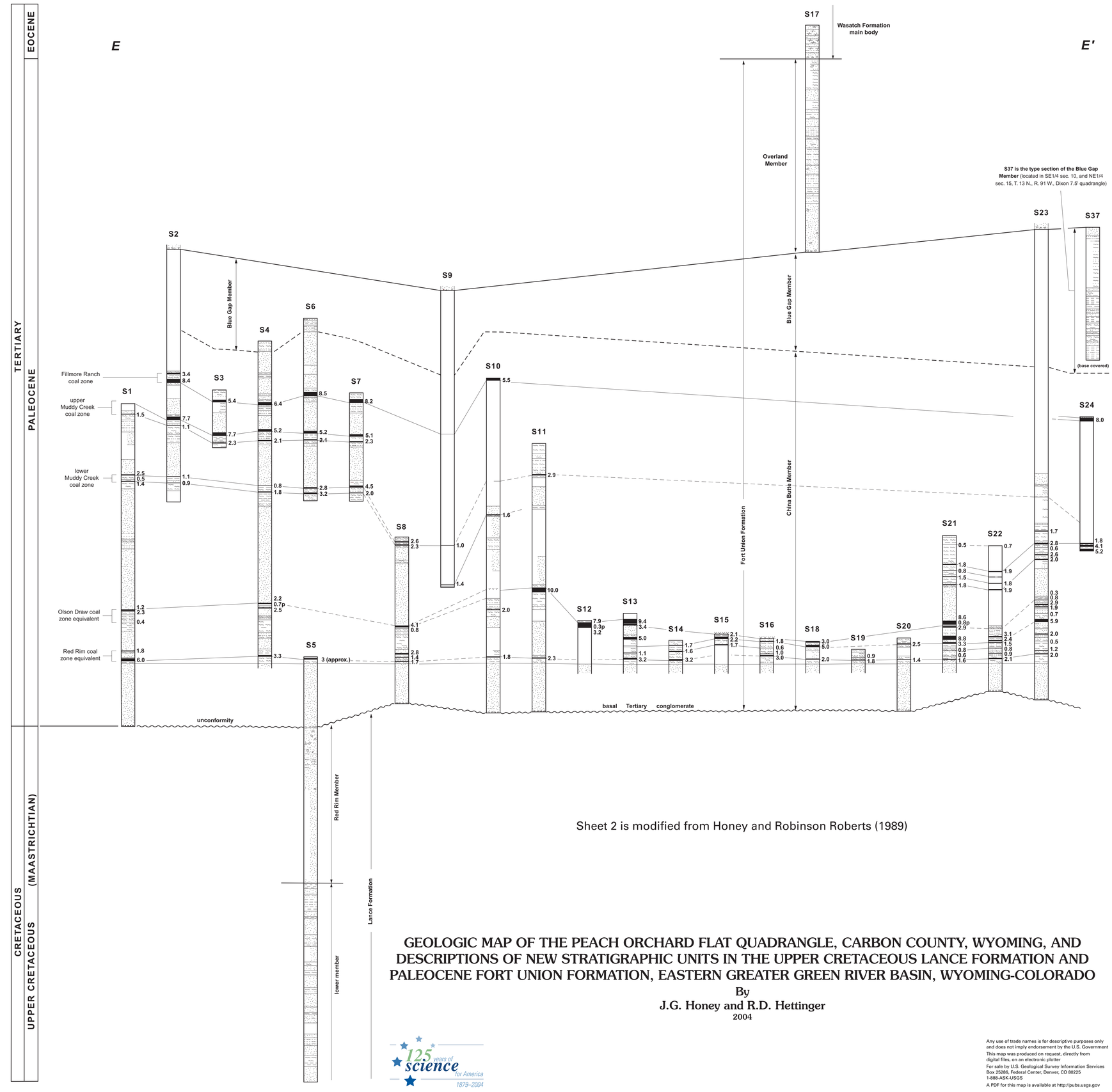
Correlation line—Dashed line indicates probable correlation

Pinchout of lithology—Dashed line indicates probable correlation of pinchout



Note: The conglomerate shown in measured sections S1 and S10 of cross sections A-A' and B-B' marks the unconformity at the Cretaceous-Tertiary boundary. The position of the unconformity was projected from the surface sections to nearby drill holes. The unconformity was then correlated in the subsurface between drill holes, based on its stratigraphic position and on its signature in the geophysical logs (spontaneous potential, resistivity, natural gamma, or density).





Sheet 2 is modified from Honey and Robinson Roberts (1989)

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

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

2004

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

SCIENTIFIC INVESTIGATIONS MAP 2835
PAMPHLET
Version 1.1

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

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INTRODUCTION

Geologic mapping of the Peach Orchard Flat 7.5-minute quadrangle (sheet 1) was done as part of a larger effort to acquire detailed data on coal-bearing Upper Cretaceous and Paleocene strata in parts of the eastern Washakie Basin and southeastern Great Divide Basin, an area extending approximately from Rawlins, Wyo., in the north to the Wyoming-Colorado State line in the south (fig. 1). Such data provide vital information critical for resource assessments and land-use-planning studies. This work included (1) mapping of individual coal beds and the boundaries of coal-bearing and adjacent formations, (2) measuring and describing surface stratigraphic sections, with the main focus on coal-bearing units, and (3) study of geophysical logs to determine subsurface coal thicknesses and formation boundaries. The primary coal-bearing unit is the Paleocene Fort Union Formation, with minor coal being present also in the Upper Cretaceous Lance Formation; coal in older Cretaceous strata was not addressed. Surface and subsurface correlations of coal-bearing and adjacent strata are illustrated on sheet 2 and drill holes used for correlations are identified in table 1. Additional data for several isolated coal sections are provided in table 2.

Four new lithostratigraphic units are proposed in this report: the Red Rim Member (new) is assigned to the Lance Formation, and the China Butte Member (new), Blue Gap Member (new), and Overland Member (new) are assigned to the Fort Union Formation. Locations and type sections of these new units are shown in figures 1 and 2, respectively. These four lithologically distinct units are exposed along the east flank of the Washakie Basin, southeast flank of the Great Divide Basin (except for the Blue Gap Member), and locally in the eastern Sand Wash Basin. They are also traceable in the subsurface over large distances in the eastern Washakie and Sand Wash Basins (figs. 1, 3). These units have been identified in numerous subsurface studies, including our own, and informal nomenclatures have been variously applied. Until recently, published surface mapping did not show the lithologically distinct and mappable rock units within the two formations. Several recent studies, however, have allowed initial lithologic subdivision of outcrops previously mapped as Lance and Fort Union Formations (Honey and Robinson Roberts, 1989; Honey, 1990; Hettinger and others, 1991). In this report we modify our own previous informal nomenclature and establish a formal nomenclature for major subdivisions of the Lance and Fort Union Formations. We also demonstrate the mappability of these units at a scale of 1:24,000 in the Peach Orchard Flat 7.5-minute quadrangle (sheet 1).

The areal distribution of the newly named Red Rim, China Butte, Blue Gap, and Overland Members in the eastern Washakie and southeasternmost Great Divide Basins is shown in figure 1. With the exception of the Blue Gap Member, these members are mappable at the surface from the Little Snake River to north of Interstate 80 (I-80), a distance of about 60 mi. The Blue Gap Member is present from north of the Little Snake River to the Dad arch (fig. 1), where it pinches out. Limited exposures demonstrate the presence of these units along the east flank of the Sand Wash Basin and along the east flank of the Great Divide Basin to where they are truncated by the Paleocene and Eocene Battle Spring Formation. Their areal distribution has also been

demonstrated in the subsurface of the Washakie Basin, eastern Sand Wash Basin, and extreme southeastern Great Divide Basin, where their geophysical signatures have been correlated by Honey and Hettinger (1989b), Hettinger and others (1991), and Hettinger and Kirschbaum (1991).

ACKNOWLEDGMENTS

We thank Ven Barclay and Malcolm C. McKenna for discussions regarding the stratigraphy and structure in the eastern part of the Greater Green River Basin. We also thank Steve Roberts and Steve Hasiotis for their contributions regarding Paleocene strata in the region. Joseph East and Anna Scarbrough are gratefully acknowledged for digitizing the geologic map of the Peach Orchard Flats quadrangle. Alessandro J. Donatich is acknowledged for editing and layout of the map and text. We also appreciate the comprehensive reviews by Ron Johnson and Malcolm C. McKenna, and the editorial review by William Keefer.

DISCUSSION OF NEW MEMBERS OF THE LANCE AND FORT UNION FORMATIONS

RED RIM MEMBER (NEW) OF THE LANCE FORMATION

The Red Rim Member is herein named for the sandstone-dominated upper part of the Upper Cretaceous Lance Formation in the eastern Sand Wash, Washakie, and southeastern Great Divide Basins; it lies stratigraphically between the superjacent China Butte Member (new) of the Fort Union Formation and the subjacent lower member of the Lance Formation. It is named for Red Rim, a prominent ridge extending southwest from I-80 in sec. 13, T. 21 N., R. 89 W. (just north of top border of fig. 1) to Separation Creek in sec. 9, T. 19 N., R. 90 W. (fig. 1). The cliffs and dip slopes of Red Rim are composed of sandstones that characterize the member. Hettinger and others (1991, their measured section J) measured a partial section at the south end of Red Rim (loc. J on fig. 1). However, the sandstones in the lower and upper parts are not well exposed at locality J. Consequently, we chose an area farther south as the type section, where good exposures show both the upper and lower contacts of the member. The type section (loc. 4 on fig. 1) is in an area referred to locally as the "Cedars," located astride the Dad arch near State Highway 789. The base of the section is located 2,500 ft FEL (from the east line) and 700 ft FSL (from the south line), and the top is located 1,200 ft FWL (from the west line) and 1,000 ft FSL, in sec. 3, T. 16 N., R. 92 W., in the Doty Mountain 7.5-minute quadrangle (fig. 1). The measured type section is shown graphically in figure 2.

The Red Rim Member is widely distributed across the eastern part of the Greater Green River Basin, where its exposures form prominent reddish-orange cliffs in the southeastern Great Divide Basin, just north of Separation Creek at the south end of the Riner 7.5-minute quadrangle (fig. 1). Exposures are discontinuous south of Separation Creek and lack red coloration, being light gray to yellowish gray. Outcrops of the member have been correlated with subsurface homotaxial rocks in the eastern Washakie and Sand Wash Basins (Honey and Hettinger, 1989b; Hettinger and others, 1991), and westward across the Washakie Basin nearly to the Rock Springs uplift where the unit is absent due to pre-Fort Union erosion (Hettinger and Kirschbaum, 1991). The Red Rim Member is equivalent to the lower and middle zones of the unnamed Cretaceous and Tertiary sandstone unit of Honey and Hettinger (1989b), Hettinger and others (1991), and Hettinger and Kirschbaum (1991). Additional studies by Tyler and McMurry (1994) also showed that equivalent sandstones are present throughout the Sand Wash Basin, but thin considerably toward the northwest corner of the basin, and are removed entirely by erosion near the Rock Springs uplift.

The Red Rim Member is about 685 ft thick at the type section. It thins to the south to about 370 ft near Baggs, Wyo., just north of the State line (fig. 1), and to about 210 ft in the southeast Sand Wash Basin. To the north it thickens to about 915 ft in the subsurface near Red Rim. Regional thickness trends are shown in figure 3. The member consists of thick, superposed, multistoried sandstone bodies as much as 200 ft thick that are separated by relatively thin layers of silty shale, carbonaceous shale, and mudstone that are typically less than 20 ft thick, but may be as much as 100 ft thick. In the Washakie Basin, the Red Rim Member displays an overall coarsening-upward grain size, as described for the lower and middle zones of the unnamed Cretaceous and Tertiary sandstone unit by Hettinger and others (1991). The lower part of the member contains fine- to medium-grained sandstone with rare chert pebbles, and the upper part contains medium- to coarse-grained sandstone with abundant chert pebbles. Individual sandstones in multistoried units are commonly trough crossbedded with basal lag deposits consisting of claystone and siltstone clasts (lower parts of the Red Rim Member), or siltstone and claystone clasts and chert pebbles (higher parts of the Red Rim Member). We interpret these sandstones as fluvial channel deposits. Their physical characteristics and thickness trends are discussed more fully in Hettinger and others (1991).

The base of the Red Rim Member is generally poorly exposed, and is placed at the base of the first major sandstone in a succession of thick sandstones that characterize the upper part of the Lance Formation. On geophysical logs, individual sandstones are recorded with blocky signatures and may be several hundred feet thick (fig. 2). Subsurface correlations by Hettinger and others (1991) showed the basal contact to intertongue with underlying strata; however, abrupt increases in sandstone thickness and grain size above the contact indicate the contact may in fact be unconformable. Where exposed on outcrop, the Red Rim Member overlies the lower member of the Lance Formation along a sharp contact. If an unconformity exists at

this level, it is probably of lesser magnitude than the Cretaceous-Tertiary unconformity that marks the top of the member (see discussion under China Butte Member). The magnitude of the Cretaceous-Tertiary unconformity increases westward across the Washakie Basin, as indicated by its angular discordance with underlying strata (Hettinger and Kirschbaum, 1991).

The Red Rim Member is distinguished from the lower member of the Lance by having (1) thicker and more laterally extensive sandstones that become increasingly coarser grained higher in the member and (2) little to no mudrock (fig. 2). In contrast, the lower member of the Lance is generally characterized by thick units of gray and yellow-brown mudstone, siltstone, and carbonaceous shale, with subordinate amounts of thin lenticular sandstone; a few coals are also present mainly in the basal 100 ft. The Red Rim Member is separated from the overlying coal-bearing China Butte Member of the Fort Union Formation by a conglomerate marking a regional unconformity. A detailed measured section of the Lance Formation was illustrated in Hettinger and others (1991, lower part of their measured section C). The line of measured section C is shown as locality C on figure 1 and the described lithologies are shown in figure 2. The part of measured section C that extends across the Lance Formation is labeled MSA (secs. 28, 29, 32, and 33, T. 15 N., R. 91 W.) on the geologic map of the Peach Orchard Flat 7.5-minute quadrangle (sheet 1).

Based on palynological analysis, the Red Rim Member is Late Cretaceous in age (late but not latest Maastrichtian). Sample localities and palynomorphs for the member in the eastern Washakie Basin are listed in Hettinger and others (1991); palynomorph localities D6473 and D6474 are shown on the geologic map in the vicinity of MSA (sheet 1).

CHINA BUTTE MEMBER (NEW) OF THE FORT UNION FORMATION

The China Butte Member of the Fort Union Formation is named herein for an interval of interbedded sandstone, siltstone, mudstone, carbonaceous shale, and coal that constitutes the lower part of the Fort Union Formation in the eastern Washakie, Sand Wash, and Great Divide Basins; the basal part also contains some conglomerate. In the eastern Sand Wash and southeastern Washakie Basins, the member lies stratigraphically between the underlying Red Rim Member of the Lance Formation and the overlying Blue Gap Member (new) of the Fort Union Formation (fig. 3). North of the Dad arch the Blue Gap Member pinches out (see below), and the China Butte Member lies between the Red Rim Member of the Lance Formation and the Overland Member (new) of the Fort Union Formation. The name is derived from China Butte, located in the northeastern part of the Doty Mountain 7.5-minute quadrangle. Because only part of this coal-bearing unit is present at China Butte, the type section (loc. 3, fig. 1) is located in the "Cedars" area: the base of the measured section is 1,200 ft FWL and 1,000 ft FSL of sec. 3, T. 16 N., R. 92 W., in the Doty Mountain 7.5-minute quadrangle; the top of the measured section lies on the section line between secs. 4 and 9, and 1,950 ft from the southeast corner of sec. 4, T. 16 N., R. 92 W., in the Duck Lake 7.5-minute quadrangle. Lithologies in the type section of the China Butte Member are shown in figure 2 and were previously shown as part of measured sections G and H in Hettinger and others (1991). Equivalent strata were previously assigned to the lower zone (or lower part) of the Fort Union Formation and the upper zone (or upper part) of the unnamed Cretaceous and Tertiary sandstone unit (Hettinger and others, 1991; Honey and Hettinger, 1989b).

Exposures of the China Butte Member typically form valleys and ridges, with the valleys formed by gray and brown mudstone and claystone, and the ridges capped by yellowish-gray sandstone. Clinker locally forms prominent red outcrops, as at China Butte itself. The member is mappable at the surface and traceable in the subsurface over the same area as the Red Rim Member of the Lance Formation. Westward across the Washakie Basin, the upper part has been correlated with the lower part of the Fort Union Formation on the east flank of the Rock Springs uplift, indicating that rocks equivalent to the lower part of the member were probably not deposited in the Rock Springs area (Hettinger and Kirschbaum, 1991). Equivalent coal-bearing rocks are present throughout the Sand Wash Basin (Tyler and McMurry, 1994).

Lithologies and thickness trends of the China Butte Member (fig. 3) were summarized in Hettinger and others (1991), and detailed lithologic descriptions from exposures in the Baggs 15-minute quadrangle (includes the Peach Orchard Flat, Smiley Draw, Dixon, and Baggs 7.5-minute quadrangles) were provided by Honey (1984). Cross references between measured sections shown on the geologic map of the Peach Orchard Flats 7.5-minute quadrangle and Honey (1984) are given in table 3. The China Butte Member contains repetitive, fining-upward cycles consisting of a thick basal sandstone overlain successively by siltstone, claystone, carbonaceous shale, and coal. The basal sandstone may be as thick as 220 ft, although it is generally much thinner, and the finer grained upper coaly part is as much as 80 ft thick. Coals vary in thickness to a maximum of 40 ft and are commonly overlain by a few feet of mudrock; the coal or the overlying mudrock is overlain directly by the basal sandstone of the next cycle. These basal sandstones are typically light to yellowish gray and multistoried, and vary in grain size from fine to coarse with the medium- and coarse-grained sandstones confined to the lower part of the member. Coal distribution and continuity in the China Butte Member are shown in various reports including Edson (1979), Hettinger and Kirschbaum (1991), Hettinger and others (1991), Honey (1990), Honey and Hettinger (1989a, b), and Honey and Robinson Roberts (1989), as well as on sheet 2 of this report.

In the eastern Washakie Basin, the lowest unit in the China Butte Member (shown by a pattern on the geologic map) is a multistoried sandstone, as much as 220 ft thick. This unit typically grades upward from a conglomerate and (or) conglomeratic sandstone in the basal 2–75 ft to a medium- to coarse-grained sandstone. Conglomerate pebbles are predominantly gray and black chert, with minor white and pink quartzite, quartz, and porphyritic felsic igneous rock. This lowest multistory sandstone previously constituted the upper zone (or part) of the unnamed Cretaceous and Tertiary sandstone unit of Honey and Hettinger (1989b) and Hettinger and others (1991). The basal conglomerate overlies an unconformity that separates rocks of Late Cretaceous age from rocks of Tertiary age; the youngest Maastrichtian is missing as indicated by the highest palynomorph samples obtained from the underlying Red Rim Member of the Lance Formation. This multistoried sandstone unit is the basal fluvial channel deposit of the Fort Union Formation and is part of the lowest fining-upward cycle, inasmuch as it is overlain by mudstone and coal.

The China Butte Member was mapped from the Wyoming-Colorado State line north to I-80. North of I-80, the member forms steeply dipping exposures on the west flank of the Rawlins uplift. The prominent basal conglomerate and conglomeratic sandstone have also been traced from a few miles north of the Little Snake River to the southern part of the Riner 7.5-minute quadrangle (fig. 1). From there north to I-80, exposures are poor and the base of the member is inferred from aerial photographs. As explained in Hettinger and others (1991), the basal conglomeratic interval on well logs was picked as a strong deflection (representing coarse-grained lithologies) at a stratigraphic position compatible with that known from surface studies. Logs were supplemented with descriptions of drill hole cuttings, where available. The upper contact of the China Butte Member is placed at the base of the massive claystones and siltstones of the overlying Blue Gap Member from the southeastern Sand Wash Basin to the Dad arch in the eastern Washakie Basin, where the Blue Gap Member pinches out. Farther north, the upper contact of the China Butte Member is placed beneath the basal sandstones of the Overland Member, which are coarse grained to granulitic from the Dad arch to the Continental Divide, and locally conglomeratic north of I-80 on the west flank of the Rawlins uplift. Extensive cover is present between the Continental Divide and I-80, and the top contact of the member is necessarily inferred from aerial photographs.

The China Butte Member is about 1,060 ft thick at the type section. It thins to the south, to about 735 ft near Baggs, and to as little as 500 ft in some wells in the eastern Sand Wash Basin. It thickens north of the type section, to between 2,000 and 2,160 ft in the subsurface near Red Rim; this thickening is accomplished in part through the addition of coal-bearing beds in the lower part of the member, and in part by the inclusion of beds in the upper part of the member that are laterally equivalent to the Blue Gap Member (fig. 3). Just north of I-80 on the west flank of the Rawlins uplift, a measured surface section shows the China Butte Member to be at least 2,180 ft thick; however, the member thins farther north due to facies changes and erosional truncation (Honey and Roberts, 1994).

As detailed in Hettinger and others (1991), the age of the China Butte Member is early Paleocene. Palynological samples collected in the eastern Washakie Basin from the basal sandstone and basal coal beds contain early Paleocene palynomorphs typical of zone P2 of Nichols and Ott (1978). U.S. Geological Survey (USGS) palynomorph localities D6779A and D6779B (Hettinger and others, 1991) were collected from the member's lowest coal bed in the Peach Orchard Flat 7.5-quadrangle (sheet 1) and dated as early Paleocene (zone P2). Palynomorphs characteristic of zone P1 have not been found south of the Rawlins uplift. Vertebrate fossils also indicate a Paleocene age for the China Butte Member; fossils from the middle and upper parts in the Blue Gap quadrangle (fig. 1) are Torrejonian (early Paleocene) in age (Rigby, 1980—Swain Quarry and other localities; Hettinger and others, 1991). Although vertebrate fossils have not been reported previously from the base of the China Butte Member, work in progress by J.G. Honey and M.C. McKenna (Adjunct Professor, Laramie, Wyo., University of Wyoming; Curator Adjunct, Boulder, Colo., University of Colorado) indicates that north of the Dad arch the stratigraphically lowest beds are as old as Puercan (earliest Paleocene).

BLUE GAP MEMBER (NEW) OF THE FORT UNION FORMATION

The name Blue Gap Member of the Fort Union Formation is herein applied to an interval of predominantly olive- to brownish-gray claystone and mudstone between the overlying Overland Member (new) and the underlying China Butte Member of the Fort Union Formation in the southeast Washakie Basin, and between overlying rocks assigned to the Wasatch Formation and underlying rocks equivalent to the China Butte Member of the Fort Union Formation in the eastern Sand Wash Basin (fig. 3). The Blue Gap Member is mappable at the surface along the southeast margin of the Washakie Basin (fig. 1), and is traceable on subsurface geophysical logs from the Dad arch south to Craig, Colo. (Honey and Hettinger, 1989b). The Blue Gap Member is named for Blue Gap Draw, which is located directly west of outcrops of the member in sec. 24, T. 15 N., R. 92 W., Blue Gap 7.5-minute quadrangle (fig. 1). Outcrops of the Blue Gap Member are sporadic, because these clay-rich rocks are easily weathered and obscured by vegetation. However, prominent exposures are on the east bank of Muddy Creek in SE1/4 sec. 10, and NE1/4 sec. 15, T. 13 N., R. 91 W. These exposures, which show the claystone lithology most typical of the member, are visible from Wyoming State Highway 789. The type section of the Blue Gap Member (loc. 1 on fig. 1) was measured along a line beginning about 550 ft

FSL and 1,850 ft FEL, and ending about 250 ft FSL and 2,600 ft FEL, in sec. 10, T. 13 N., R. 91 W., in the Dixon 7.5-minute quadrangle. The lower part of the member is not exposed at the type section. However, complete thicknesses were obtained in the Blue Gap and Doty Mountain 7.5-minute quadrangles, where the member is considerably thinner than at the type section and in numerous well logs from the southeastern Washakie and eastern Sand Wash Basins. The entire Blue Gap Member can be seen at a location approximately 1,500 ft FEL and 1,800 ft FNL (from the north line) of sec. 34, T. 17 N., R. 92 W., in the Doty Mountain 7.5-minute quadrangle (fig. 1). On geophysical logs, the member is marked by a distinctive low resistivity interval (fig. 2), which has long been recognized by subsurface stratigraphers (Colson, 1969; Beaumont, 1979; Honey and Hettinger, 1989b; Tyler and McMurry, 1994).

Lithologies at the type section of the Blue Gap Member are shown in figure 2. Hettinger and others (1991) previously included these rocks within their upper zone of the Fort Union Formation and depicted the strata in their measured sections A, D, and G. Measured section A of Hettinger and others (1991) is here designated the type section of the Blue Gap Member. The dominant lithologies are claystone and mudstone; however, some thin interbeds of fine-grained sandstone, siltstone, rare ironstone, and carbonaceous shale are also present. Plant rootlets and fragments are common. A detailed description of the type section is given in this report in the "Description of Map Units" on sheet 1. In the southeastern Washakie Basin, from the "Cedars" area south to Muddy Creek (fig. 1), the base of the Blue Gap Member is marked by thick massive claystone, silty claystone, or siltstone resting on a dip-slope-forming ironstone that is 0.5–1 ft thick, reddish purple to grayish black, silty, sandy, and commonly concretionary. South of Muddy Creek the basal strata are commonly covered, as at the type section, but where exposed the claystones are in sharp contact with the underlying medium-grained sandstone. The upper boundary in the eastern Washakie Basin is also sharp, being recognized by the abrupt grain-size increase in the basal sandstones of the overlying Overland Member. Near Craig, Colo., in the southeastern Sand Wash Basin, the Blue Gap Member is directly overlain by a conglomerate and arkosic sandstones assigned to the basal part of the Wasatch Formation (M. Brownfield, USGS, oral commun., 1985). Based on earlier subsurface correlations (Honey and Hettinger, 1989b), the lower part of the Wasatch Formation in the southeastern Sand Wash Basin was interpreted to be equivalent to the lower part of the Overland Member of the Fort Union Formation to the north.

The Blue Gap Member is wedge shaped in a north-south direction in the eastern Washakie and Sand Wash Basins, thinning from a maximum thickness of about 570 ft in the eastern Sand Wash Basin to 0 ft in the "Cedars" area on the Dad arch (fig. 3). At the type section a partial thickness of 290 ft was measured. It is not present north of the Dad arch and its westward extent across the Washakie Basin is unknown. Tyler and McMurry (1994) noted that the member (their "gray-green mudstone unit") is present and thick along the east and west margins of the Sand Wash Basin, but is absent in the center of the basin because of erosion by the superjacent Overland Member of the Fort Union Formation (their "basin sandy unit" of the Fort Union Formation). Our geologic mapping in the Blue Gap 7.5-minute quadrangle just north of the Peach Orchard Flat 7.5-minute quadrangle shows local removal of the Blue Gap Member beneath the basal sandstone of the Overland Member in SW1/4 sec. 34, T. 16 N., R. 92 W. This evidence for erosion of the upper part, combined with the abrupt upward grain-size change at the boundary, indicates a probable unconformity between the two units.

No fossils useful for dating purposes have been found in the Blue Gap Member. However, its age is constrained by the early Paleocene (Torrejonian) Swain Quarry fossil mammal locality in the underlying China Butte Member, and by late Paleocene palynomorphs and transitional early/late Paleocene (Torrejonian/Tiffanian) vertebrate fossils in the lowest part of the overlying Overland Member (see respective discussions).

OVERLAND MEMBER (NEW) OF THE FORT UNION FORMATION

The Overland Member of the Fort Union Formation is here designated for a distinctive succession of predominantly light-gray sandstone, siltstone, and mudstone that crops out between overlying variegated mudstones of the Wasatch Formation and underlying claystones of the Blue Gap Member along the southeast margin of the Washakie Basin. Farther north, beyond the pinchout of the Blue Gap Member, the Overland Member lies between the main body of the Wasatch Formation (and its Battle Spring Formation equivalent) and the underlying China Butte Member of the Fort Union Formation. The Overland Member commonly weathers to light-gray to white, fluted badlands topography. The name is taken from the Overland Trail, which passes across exposures in the Doty Mountain 7.5-minute quadrangle (fig. 1). The type section is located in the "Cedars" area (loc. 2 on fig. 1). The base of the section is about 2,150 ft FEL and 1,300 ft FSL, in sec. 34, T. 17 N., R. 92 W., and the top is 600 ft FWL and 1,150 ft FSL of sec. 34, T. 17 N., R. 92 W., in the Doty Mountain 7.5-minute quadrangle. Lithologies at the type section are shown in figure 2. These rocks were previously referred to as the "unnamed upper Paleocene unit" (Honey and Hettinger, 1989b; Hettinger and others, 1991), and lithologies at the type section were shown as part of measured section G of the latter report. The member forms intermittent, light-gray badlands from the banks of the Little Snake River in the south to the west flank of the Rawlins uplift in the north, with the most spectacular badlands present in the "Cedars" area and in prominent escarpments along the Continental Divide in the southwestern part

of the Seaverson Reservoir 7.5-minute quadrangle (fig. 1).

The Overland Member is 925 ft thick at its type section (loc. 2 in fig. 1). It thins considerably to the south and is 425 ft thick in sec. 21, T. 14 N., R. 91 W., in the Peach Orchard Flat 7.5-minute quadrangle (measured section B in Hettinger and others, 1991; measured section S17 of this report). To the north, the Overland Member thickens to at least 2,271 ft on outcrop (Hettinger and others, 1991, their measured section K); the location of measured section K is shown on figure 1. Regional variations in lithology and thickness are shown in figure 2 and have been described previously by Honey and Hettinger (1989b) and Hettinger and others (1991) (their "unnamed upper Paleocene unit").

Regional studies show that the Overland Member is widespread in the eastern Greater Green River Basin (fig. 3). Outcrops are present along the entire eastern margin of the Washakie Basin and extend northward into the southeast Great Divide Basin. In the subsurface of the Washakie Basin, the member is characterized by a variety of geophysical signatures. In that area, the base is recognized by prominent resistivity deflections that record the influx of abundant, generally thick sandstones atop the Blue Gap or China Butte Members (fig. 2). The remainder of the Overland Member is characterized mainly by subdued deflections characteristic of fine-grained lithologies, except where coal signatures are present in the Cherokee coal zone. The resistivity change between the Blue Gap Member and the Overland Member can be traced southward in geophysical logs along the eastern margin of the Sand Wash Basin to just north of Craig, Colo. (Honey and Hettinger, 1989b). Rocks equivalent to the Overland Member have also been correlated in the subsurface westward across the Washakie Basin to the upper part of the Fort Union Formation on the east flank of the Rock Springs uplift (Hettinger and Kirschbaum, 1991, their "unnamed upper Paleocene unit").

In the Washakie and southeastern Great Divide Basins, the Overland Member includes a basal sandstone zone and an overlying thick fine-grained interval. In the northeastern part of the Washakie Basin and extreme southeastern part of the Great Divide Basin, the highest part contains the Cherokee coal zone (fig. 3). The basal sandstone zone is less than 100 ft thick south of the Dad arch; it is mostly covered north of the arch but geophysical logs show it to be as much as 1,050 ft thick in the subsurface. The thickness variations seem to be related to facies changes with the overlying fine-grained interval (fig. 3). The basal sandstone zone consists of light-gray sandstones, which are generally coarse grained and contain lenses of quartz and feldspar granules and chert pebbles. To our knowledge, this marks the lowest stratigraphic interval containing coarse grains and pebbles above the basal sandstone zone of the China Butte Member of the Fort Union Formation. The overlying fine-grained interval is 200 to more than 1,050 ft thick (the 1,050-ft figure represents an incomplete thickness due to cover); thickness variations are related in part to an unconformity at the top of the Overland Member (fig. 3). The fine-grained interval consists of light-gray, massive, fine-grained sandstone, sandy siltstone, and mudstone; subordinate lithologies include crossbedded sandstone and thin, tabular, sandy ironstone. In the extreme southeastern part of the Great Divide Basin, the fine-grained interval is also characterized by carbonaceous shales, generally thin calcareous sandstones, and coals. Crayfish burrows are common in the fine-grained interval south of the Continental Divide, and in exposures of the Overland Member on the west flank of the Rawlins uplift (Hasiotis and Honey, 2000). Between the Continental Divide and the Rawlins uplift, however, crayfish burrows are rare in outcrops. In the Cherokee coal zone, coal beds as much as 35 ft are present (Sanders, 1975).

As discussed in Honey and Hettinger (1989b) and Hettinger and others (1991), previous studies have placed rocks equivalent to the Overland Member into either the Fort Union or Wasatch Formations. On the eastern flank of the Greater Green River Basin, outcrops of the Overland Member have typically been mapped as part of the Fort Union Formation for which Paleocene ages have been documented. However, in subsurface correlation studies of the eastern Greater Green River Basin, these rocks have usually been placed in the Wasatch Formation with an assumed Eocene age (see discussion in Hettinger and others, 1991). Recently, in the Sand Wash Basin, Tyler and McMurry (1994) divided these strata into two informal units of the Fort Union Formation: their "basin sandy unit" corresponding to our basal sandstone zone of the Overland Member, and their "upper shaly unit" corresponding to the higher, finer grained parts of the Overland Member in the Washakie Basin.

Over much of the study area the basal contact of the Overland Member with the underlying Blue Gap and China Butte Members is recognized by the abrupt upward increase in grain size, being marked by the appearance of sandstone containing a large allogenic component of quartz, feldspar, chert granules, and pebbles. Variations in grain size in the basal sandstone zone are common throughout the study area. Clasts are largest from a few miles north of the Little Snake River to Muddy Creek (fig. 1), but become progressively finer grained northward to the vicinity of I-80. For example, from the "Cedars" area north to the Continental Divide, exposures of the basal sandstones contain relatively minor amounts of granules and pebbles, and north of the Continental Divide limited exposures of the basal sandstone are characterized by medium- to coarse-grained sandstone. Farther north on the west flank of the Rawlins uplift, however, basal sandstones of the Overland Member are again coarse grained to conglomeratic. We interpret the widespread and sharp juxtaposition of these coarse-grained to pebbly sandstones at the base of the Overland Member atop finer grained strata of the Blue Gap and China Butte Members to represent a regional unconformity.

Additional lines of evidence that indicate the Overland Member was deposited on an unconformity extending across most of the Great Divide, Sand Wash, and Washakie Basins include:

(1) In the Sand Wash Basin, Tyler and McMurry (1994) contended that their "basin sandy unit" (lower sandy part of the Overland Member) lies disconformably on the "gray-green mudstone unit" (Blue Gap Member) or the "lower coal-bearing unit" (China Butte Member); they also indicated that the "gray-green mudstone unit" (Blue Gap Member) has been completely removed in the center of the Sand Wash Basin.

(2) Near Craig, Colo., greenish-gray sandy mudstones of the Blue Gap Member are sharply overlain by conglomerates assigned either to the Wasatch Formation or to the "basin sandy unit" of the Fort Union Formation (Honey and Hettinger, 1989b; Tyler and McMurry, 1994). Geophysical correlations (Honey and Hettinger, 1989b) indicate that these conglomerates are laterally equivalent to the lower sandstones of the Overland Member.

(3) In the southeast Washakie Basin (as noted in the discussion of the Blue Gap Member), the base of the Overland Member is marked by a sharp increase in grain size, and is locally erosional into the Blue Gap Member.

(4) Although the lower contact of the Overland Member is poorly exposed in the area between the Continental Divide and I-80, geophysical logs there and to the west record an influx of stacked, thick sandstone bodies above the contact. This thick, basal sandstone zone of the Overland Member is present in the middle of the Washakie Basin, but thins westward toward the Rock Springs uplift according to Hettinger and Kirschbaum (1991); their cross section indicates that the lower contact of the basal sandstone of the Overland Member may correlate with an intraformational unconformity on the east flank of the Rock Springs uplift noted by Roehler (1979a, b), which raises the possibility that the base of the Overland Member is disconformable across the entire Washakie Basin.

(5) On the west flank of the Rawlins uplift, the base of the Overland Member locally overlies the China Butte Member with angular discordance (Barlow, 1953, 1955; Honey and Roberts, 1994). Honey and Roberts (unpub. data) measured an angular discordance of 39°. Barlow previously measured a 45° discordance, and placed Overland Member-equivalent strata into the Wasatch Formation.

Upper contact relations of the Overland Member were discussed in detail by Hettinger and others (1991, their "unnamed upper Paleocene unit"). In general, the contact is marked by a sharp increase in grain size associated with the overlying Wasatch Formation. From just north of Baggs to the "Cedars" area, the base of the overlying Wasatch Formation is marked by conglomerate and conglomeratic sandstone that separates light-gray rocks of the Overland Member from variegated mudstones of the main body of the Wasatch. However, along the Little Snake River several thin conglomerates are near the top of the Overland Member, and the distinctive marker conglomerate at the base of the Wasatch is apparently absent; therefore, at that location, the top of the Overland Member is placed beneath the lowest variegated mudstones. North of the "Cedars" area, fine-grained rocks of the Overland Member are overlain by coarse-grained arkosic sandstone lithologically and stratigraphically equivalent to the Battle Spring Formation in the Great Divide Basin. North of I-80, on Windy Hill in T. 21 N., R. 91 W., the top of the Overland Member is marked by an intensively crayfish-burrowed, hard sandstone that separates dark-gray mudstones at the top of the Cherokee coal zone from siltstones and arkosic sandstones of the overlying Battle Spring Formation (Hasiotis and Honey, 2000, their fig. 10A). Farther north and east, on the west flank of the Rawlins uplift, arkosic sandstones of the Battle Spring Formation overlie burrowed sandstone of the Overland Member with angular discordance. These relations are interpreted to indicate that the upper contact of the Overland Member is probably an unconformity all along the eastern Washakie and southeastern Great Divide Basins and part way across the Washakie Basin to the west. However, in the northeast Sand Wash Basin, the more subtle lithologic change marking the Wasatch–Fort Union boundary raises the possibility that the two formations are locally conformable there.

The age of the Overland Member in the eastern Washakie and southeastern Great Divide Basins, based on palynomorphs, is late middle and late Paleocene (palynomorph zones P3 or P4 through P6 of Nichols and Ott, 1978), and vertebrate fossils indicate a latest Torrejonian to early Tiffanian age for the rocks at or near the base of the member (Hettinger and others, 1991). On the east flank of the Rock Springs uplift, probable correlative rocks of the upper part of the Fort Union Formation are Tiffanian and Clarkforkian in age (Hettinger and Kirschbaum, 1991).

In summary, the Overland Member is named in this report for lithologically distinctive rocks of late Paleocene age. These rocks have been traditionally mapped on outcrop in the eastern Greater Green River Basin as part of the Fort Union Formation, and we follow the traditional usage. The basal contact of the Overland Member and stratigraphically equivalent rocks is unconformable over large areas in the Sand Wash, Washakie, and southeast Great Divide Basins. The upper contact also represents an unconformity in the eastern Washakie and southeast Great Divide Basins. If continued study supports the presence, over wide areas, of unconformities at the base and top of the Overland Member, then this, in combination with the distinctive lithology of this rock unit, may warrant the eventual elevation of the Overland Member to formation status.

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