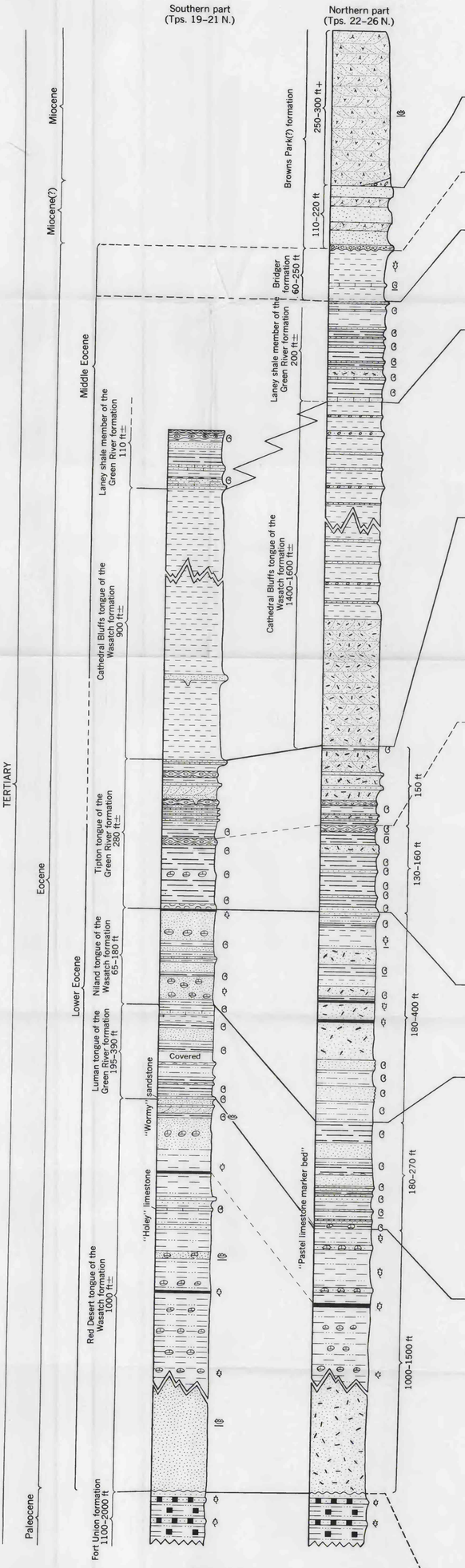

Sandstone, pinkish-gray, fine-grained, tuffaceous, crossbedded, weathers into rounded hills. Unit is lithologically indistinguishable from beds of middle Miocene age northeast of the area in the vicinity of Split Rock, Wyo. which have been assigned to the Browns Park formation by McGrew (1951). Contact with the underlying unit is gradational. Locally has lenticular basal conglomerate

Sandstone, pinkish-gray to yellowish-white, coarse-grained, crossbedded, interbedded with fine-grained tuffaceous sandstone; a few beds are calcareous and form weak ledges. Intertongues with the underlying unit

Conglomerate of pebbles, cobbles, and boulders of brown quartzite, brown and black chert, pink granite, and various greenish-gray metamorphic rocks as much as 1 foot in diameter; makes Cyclone Rim

UNCONFORMITY

Claystone and shale, grayish-green; contains several thin beds of grayish-white fossiliferous fresh-water limestone and some thin beds of gray to greenish-white algal chert. Fossil tree stumps replaced by black chert occur locally. Mollusks and ostracodes in limestone are of middle Eocene age. The contact with the underlying formation is gradational

Oil shale interbedded with fine- and coarse-grained sandstone. The oil shale is brown and contains thin layers of fibrous calcite with cone-in-cone structure. The fine-grained sandstone is yellow to orangish brown, calcareous, and fossiliferous, and weathers into prominent resistant ledges. Mollusks are of middle Eocene age. The coarse-grained sandstone is yellowish white, arkosic, and moderately calcareous, and weathers into slopes or weak ledges. The top of the formation is a persistent bed of green and white chert containing lobate algal structures. The contact with the underlying formation is gradational and intertonguing

Claystone, red and green banded; weathers into "elephant backs," "honey combs," and other badland forms; locally interbedded with conglomerate and grayish-green to grayish-white coarse-grained arkosic sandstone. Locally, the unit consists almost entirely of arkosic sandstone. No diagnostic fossils were found in this sequence, but because of its intertonguing relation to the overlying Laney shale member, the upper part, at least, may be of middle Eocene age.

In the southern part of the area, the contact of the Cathedral Bluffs tongue with the overlying Laney shale member is abruptly gradational and is drawn at the base of a sequence of green and brown oil shale, oolitic sandstone, and marl that is characteristic of the Laney shale member. Along the Laney Rim, red and green claystone beds, ranging from 1 to 10 feet in thickness, are as much as 80 feet above the base of the Laney shale member, which thickens westward from 2 to 8 feet per mile at the expense of the underlying Cathedral Bluffs tongue. This indicates intertonguing. The algal bed at the top of the section makes the Laney Rim

Sandstone, gray and buff, interbedded with green clay shale and minor amounts of brown oil shale. The unit is shalier in the southern part of the area. The sandstone is predominantly fine grained, calcareous, and ripple marked, and makes brown slabby resistant ledges. A few beds of coarse-grained crossbedded red and yellow banded channel sandstone occur in the southern part of the area, and several thick tongues of very coarse grained yellowish-tan arkosic sandstone occur in the northern part. The shale contains numerous concentrically layered calcareous algal balls averaging 1 foot in diameter, but which are locally loglike and as much as 10 feet long and 2 feet in diameter.

The top of the Tipton tongue is chosen as the stratigraphically highest bed of green clay shale, brown oil shale, or fine-grained calcareous ripple-marked ledge-forming sandstone. In the southern part of the area, the contact with the overlying Cathedral Bluffs is sharp. In the northern part of the area, the contact is arbitrary inasmuch as the typical red beds of the Cathedral Bluffs tongue are separated from the underlying ledgy sandstone beds of the Tipton tongue by 200–400 feet of massive crossbedded very coarse grained buff arkosic sandstone, which contains at least two thin beds of brown oil shale

Oil shale, brown; contains a few thin beds of coarsely crystalline limestone with obscure concentric algal markings and a few thin layers of argillaceous limestone concretions that weather yellow buff. The change from brown oil shale, typical of the lower part of the Tipton tongue, to the sandstone and clay shale typical of the upper part coincides approximately with the first appearance of conspicuous well-formed algal balls. In the Niland basin area, in Tps. 24 and 25 N., R. 95 W., the top of the oil-shale beds of the lower part of the Tipton contains a zone of algal ball layers 10 feet thick. The top layer of the zone is associated with a thin lenticular yellow limestone bed that contains ostracodes of early Eocene age. The contact of the Tipton tongue with the underlying unit is generally concealed but may be seen in the east-central part of sec. 23, T. 24 N., R. 96 W., where a highly fossiliferous brown calcareous sandstone at the base of the Tipton tongue conformably overlies a sandstone bed at the top of the underlying unit.

South of Highway 30, the stratigraphically lowest bed of well-formed conspicuous algal balls marking the top of the lower part of the Tipton occurs 20 feet below the top of the highest oil-shale bed. In this part of the area, the base of the Tipton tongue is well exposed. The lower 1–5 feet of the Tipton consists of a loosely cemented coquina of mollusks. East of Red Desert Station on the Union Pacific Railroad, the coquina rests directly on a coal bed at the top of the underlying sequence. West of Red Desert Station, the coal bed pinches out, and the coquina rests on sandstone. The contact is sharp but conformable

Interbedded clay shale, siltstone, sandstone, and oil shale. The clay shale and siltstone are greenish gray and contain many coal beds. The sandstone is fine grained and calcareous and forms ledges that weather brown. In the northern part of the area, some of the sandstone beds are arkosic and loosely cemented, and form slopes. The oil shale is typically brown. Leaves and mollusks of early Eocene age were collected from beds ranging from 80 to 100 feet below the top. This unit rests conformably on the oil shale (tongue 3) at the top of the underlying sequence

Interbedded oil shale, sandstone, siltstone, and clay shale. The oil shale is brown and makes up most of the thickness of this unit in the northeast and southeast parts of the map area. The sandstone is yellowish tan, fine grained, calcareous, and highly fossiliferous, and makes conspicuous persistent ledges. These ledges are particularly prominent in the northwestern part of the area. The siltstone and clay shale beds are usually grayish green and display fine varve-like bedding. Three prominent persistent oil-shale tongues were mapped, and are designated from bottom to top as tongues 1, 2, and 3. Tongue 3 is at the top of this sequence throughout the area. Tongue 1 is at the base of the sequence in the northern part of the area, and about 20 feet above the base in the southern part of the area. Tongue 1, in the northern part of the area, contains the "pastel limestone marker bed," a zone of gray and grayish-black silty limestone concretions that weather to various shades of purple, pink, yellow, buff, tan, and brown. It rests directly on a coal bed at the top of the underlying sequence. In the southern part of the area, the base of tongue 1 lies 20 feet above the "wormy" sandstone, which marks the base of this sequence in that area. The "wormy" sandstone is gray and fine grained, and contains molluscan impressions and vertical borings possibly made by worms. Ostracodes and mollusks from tongues 1 and 3 are of early Eocene age

Interbedded clay shale, siltstone, sandstone, coal, and carbonaceous shale. The shale, siltstone, and sandstone are greenish gray to grayish white. The sandstone is very fine grained and calcareous, and contains biotite, and forms ledges and loglike concretions. Ovoid calcareous siltstone and sandstone concretions that weather gray to rusty brown occur throughout the unit. Coal beds, ranging from 1 inch to 21 feet in thickness, are many and persistent. Tailings from animal burrows and auger cuttings from a zone about 300–360 feet below the top of the Red Desert tongue indicate that this part of the section consists primarily of oil shale, but the zone is almost nowhere exposed. The zone appears to contain a coal bed at its base, a coal bed about 10 feet below the top, and a thin zone of yellowish-buff-weathering limestone concretions at the top, similar to those in tongue 1 of the Luman.

A lenticular but persistent grayish-black limestone bed as much as 1 foot thick makes a good key bed in the southern part of the area. The limestone bed is about 200 feet below the top of the Red Desert tongue. Locally the surface of this bed is deeply pitted where fossil gastropods have been leached out, giving it a perforate or "holey" appearance. Only the upper 400 feet of the Red Desert tongue is exposed in the area, but in the vicinity of Bitter Creek Station on the Union Pacific Railroad it is about 1,000 feet thick. The upper 600 feet constitutes the coal-bearing part of the tongue. The lower 400 feet is not essentially coal bearing and consists of coarse-grained buff sandstone, which overlies the Fort Union formation unconformably. Vertebrate fossils in the lower part of the Red Desert tongue are of earliest Eocene age (Sand Coulee). Vertebrate fossils in the upper part of the Red Desert tongue are of middle or late early Eocene age (Lysite or Lost Cabin).

Battle Spring formation:

In the northeastern part of the area, the stratigraphic units, which in the adjoining column extend from the top of the Fort Union formation into the lower part of the Morrow Creek member, are completely replaced by beds of arkosic sandstone and subordinate amounts of impure green claystone. The impurities consist mostly of grains of clear angular quartz, feldspar, and mica. The sandstone is generally yellowish buff but locally is tinted green and red. Most of the rocks in this succession are only slightly calcareous and weather into soft sandy slopes. Locally, the more calcareous parts make low rounded cliffs and weak ledges below which the slopes are usually littered with spheroidal concretions ranging from a few inches to several feet in diameter. Most of these "cannonball" concretions are structureless and contain limonitic centers. Some of the concretions, especially those found around the rim of Niland basin and along Lost Creek in sec. 17, T. 26 N., R. 94 W., exhibit a concentric structure and weather by exfoliation of successive layers, which causes them to resemble nested hemispherical bowls containing a small "cannonball" in the center. The thickness of the arkosic sandstone beds is at least equivalent to the thickness of the units with which it intertongues (about 3,300 feet) but might be greater north and east of the area

UNCONFORMITY

Interbedded clay shale, siltstone, sandstone, coal, and carbonaceous shale, banded with various shades of gray, green, yellow, and purple. Iron-oxide concretions, commonly containing plant remains, are numerous and conspicuous throughout most of the Fort Union formation. Fort Union strata crop out in the area in the vicinity of Flattop Buttes, where the strata have yielded vertebrate fossils of late Paleocene age. West of the area, along the east flank of the Rock Springs uplift, the uppermost beds of the Fort Union formation contain plant fossils of Paleocene age

GENERALIZED COMPOSITE STRATIGRAPHIC SECTIONS OF EXPOSED ROCKS

591964 O - 61 (In pocket)