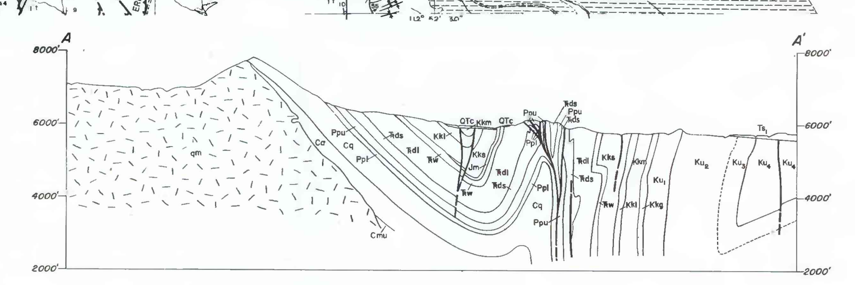
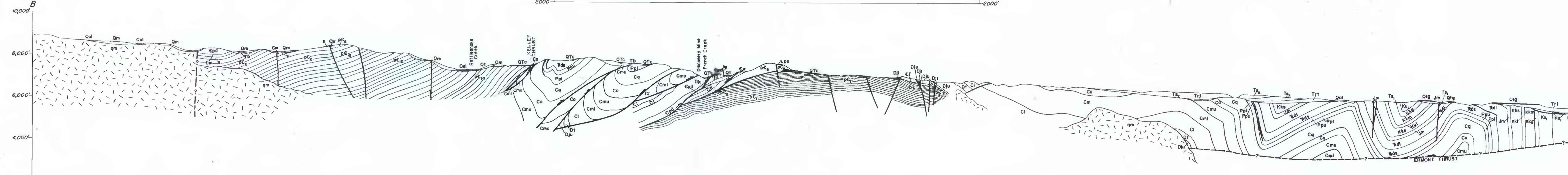
52-105

DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY

PREPARED AS PART OF THE INTERIOR DEPARTMENT PROGRAM
FOR DEVELOPMENT OF THE MISSOURI RIVER BASIN

PRELIMINARY GEOLOGY OF THE
N.W.¼ OF THE WILLIS QUADRANGLE





SECTIONS ALONG LINES A-A' AND B-B'

PLATE I

EXPLANATION

Recent

Qal

Alluvium

Transported gravel, sand, and silt along stream courses, and sandy, silty, and peaty fillings of basins of glacial origin.

Qt

Talus

Rock slides and apronlike accumulations of fresh angular blocks below steep rock crags.

Pleistocene

Qm

Glacial moraine

Unsized aggregate of granitic boulders and sand deposited during several stages of glaciation.

Qv

Valley gravel

Sandy soil and gravel, with pebbles and cobbles of resistant rocks. Forms broad, graded surfaces, locally dissected by Recent stream channels.

EROSIONAL UNCONFORMITY

Qtg

Terrace gravel

Gravel veneeer, composed dominantly of brown-stained quartzite boulders and cobbles. Formed exclusively by reworking of older tuffaceous gravel (Ts_1).

ANGULAR UNCONFORMITY

QTc

Cover

Slope wash, residual fragments, soil, weathered talus, and landslide debris. Includes some Recent deposits as well as many areas of older residual soil and slope wash formed during accumulation of tuffaceous gravel and limestone gravel units (Ts_1, and Ts_2).

Ts_2 / Ts_1

Tertiary (?) sediments

Limestone pebble gravel (Ts_2), weakly consolidated and poorly bedded gravel with sandy caliche cement; pebbles dominantly of Paleozoic limestone. Exposed thickness about 300 feet.

Tuffaceous boulder gravel (Ts_1), unconsolidated fan gravel and fan breccia, generally with reworked tuffaceous matrix. Characterized by heterogeneity of fragment size and rock type. Contains sporadic giant blocks of far-traveled quartzite up to 24 feet in length. Probably of mudflow origin in part. Exposed thickness about 500 feet.

ANGULAR UNCONFORMITY

Oligocene

Trt / Tb / Tr / Tbi / Trd

Rhyolite, basalt, and rhyolite tuff

Rhyolite (Tr), generally pink or dull red, commonly flow-banded Rhyolite dikes and small pods (Trd), white or cream-colored; massive or flow-banded (?). Basalt (Tb), iron-gray to black, fine-grained to dense flow rock, typically with visible olivene grains. Includes some reddish scoria. Intrusive basalt (Tbi), forms several small plugs. Rhyolite tuff (Trt), white to pale buff vitric-crystal tuff with fragments of bipyramidal quartz and iridescent sanadine. Dominantly air-laid; thick-bedded to massive, friable to compact; locally bentonized. Exposed thickness more than 2,000 feet.

ANGULAR UNCONFORMITY

lp

Latite porphyry

Light-gray fine-grained rock, commonly with large orthoclase phenocrysts. Occurs as sills; one flow-banded vitrophyric stock, probably of similar composition but now devitrified.

qm

Quartz monzonite

Light-gray, biotite-hornblende quartz monzonite. Coarse-grained in major pluton, medium- to fine-grained in smaller masses. Major pluton includes elongate bodies of biotite quartz monzonite, not delineated on this map

a / gd

Granodiorite, granodiorite (?) porphyry and andesite porphyry

Granodiorite and granodiorite (?) porphyry (gd), gray, medium- to fine-grained granitic rocks containing hornblende and biotite. Occur as small plutons that locally appear to grade into sills, dikes, and irregular masses of andesite porphyry (a), dark gray-green rock containing augite phenocrysts.

FOLDING AND FAULTING

Paleocene–Eocene (?)

Ta

Andesite

Gray-green to purplish-brown andesitic agglomerate and minor flows. Thin layer of light-colored trachyitic (?) tuff locally present near the base. Incomplete, crumpled sections; possibly 1,000 feet exposed.

Tt / t

Tuff and intruded trachyte porphyry

Tuff (Tt), white to cream-colored platy trachyitic (?) tuff in upper part; underlain by trachyitic (?) lapilli tuff with varying amounts of non-volcanic rock fragments, tuffaceous sandstone, and locally, tuffaceous conglomerate at or near base. Indurated and altered. Incomplete, faulted sections; possibly 2,000 feet exposed. Trachyte porphyry (t), cream-colored to pale-gray fine-grained rock with large orthoclase phenocrysts. Occurs as a plug-like mass apparently intruded into tuff (Tt). Possible source of trachytic (?) pyroclastics.

ANGULAR UNCONFORMITY

Upper Cretaceous

Ku_4 / Ku_3 / Ku_2 / Ku_1

Post-Kootenai sediments

Upper member (Ku_4), greenish-gray or light yellowish-gray, to grayish-white tuffaceous sub-graywacke, tuffaceous sandstone, quartz sandstone, and tuff, locally with conglomerate lenses. Interbedded with grayish-green, greenish-blue, and dark-gray mudstone and siltstone, in part tuffaceous. Locally contains plant fragments. Sparse flora in upper beds indicates Judith River or younger age. More than 4,000 feet exposed in northeast corner of quadrangle.

Light-colored tuff member (Ku_3), chalk-white to pale blue-green latitic (?) tuff and porcellanite. Resistant unit; thickness 250 feet in sec. 25, T. 6 S., R. 10 W., thickens northward by addition of sandstone interbeds to about 800 feet in northeast part of quadrangle.

Mudstone member (Ku_2), gray-green and olive-drab mudstone and tuffaceous mudstone. Minor amounts of greenish-gray tuffaceous and silty sandstone and a few beds of light-colored tuff. Unit forms prominent strike valley. Thickness about 1,000 feet.

Basal member (Ku_1), pale gray to pale yellow-gray sandstone, commonly cross-bedded and slabby weathering, with lesser amounts of reddish, maroon or olive-drab siltstone and mudstone. Resistant sandstone beds at top of member form prominent outcrops. Thickness about 650 feet.

Lower Cretaceous

Kkg / Kkm / Kkl / Kks

Kootenai formation

Gastropod limestone member (Kkg), light yellowish-gray to gray, massive, crystalline limestone in thick beds separated by weak shaly units. Abundant small fresh-water gastropod shells in limestone. Rock commonly smells of petroleum. Limestone beds form conspicuous lines of outcrop. Thickness about 175 feet.

Red mudstone member (Kkm), brick-red to maroon mudstone and minor red sandstone. Weak, easily eroded rocks. Thickness about 500 feet.

Fine-grained limestone member (Kkl), pale yellowish-gray to pale-drab dense limestone and shaly limestone layers with shaly interbeds. Not strongly resistant. Thickness about 175 feet.

Sandstone and mudstone member (Kks), upper part dominantly reddish and greenish mudstone; lower part comprises several ridge-forming units of coarse- to medium-grained grayish- to yellowish-brown, cross-laminated or massive sandstone, separated by units of red and green mudstone. Lenses of chert-pebble conglomerate locally present in sandstone, black chert grains give sandstone "salt and pepper" aspect. Thickness about 500 feet.

Upper Jurassic

Jm

Morrison (?) formation

Blue-green tuffaceous (?) mudstone, varicolored shaly rocks; subordinate purplish andesitic (?) lapilli tuff (?), sericitized silicic lava, dark greenish-brown impure limestone and local carbonaceous seams. Topographically weak unit; grades upward into basal Kootenai sandstone. Maximum thickness about 200 feet; locally absent by non-deposition

ANGULAR UNCONFORMITY

Lower Triassic

Ꞧw

Woodside (?) formation

Brick-red calcareous mudstone gradational from underlying limestone. Easily eroded unit. Present only in northeastern part of quadrangle, elsewhere removed by pre-Morrison erosion. Maximum thickness about 100 feet

Ꞧdl / Ꞧds

Dinwoody formation

Limestone member (Ꞧdl), upper part comprises gray- to brown-weathering limestone and calcareous sandstone, and interbedded brownish-gray shale. Lower part comprises brown-weathering thin- to thick-bedded limestone and subordinate limy shale. Widespread phosphatic linguloid brachiopod shells and manganese oxide bunches and veinlets. Thickness about 550 feet; locally thinned or removed by pre-Morrison erosion.

Shale member (Ꞧds), gray-green to drab clay shale and limy shale, with a few thin limestone layers near top. Thickness about 300-350 feet

Permian

Ppu / Ppl / Pp

Phosphoria formation

Upper Phosphoria (E member, Swanson, and others) (Ppu), black to tan chert, grayish-brown quartzite and cherty quartzite, commonly ten to several scores of feet of quartzite at the top. Probably not equivalent to the Rex chert member of Idaho. Thickness 145 feet at Kelley Gulch and Cave Gulch trenches.

Lower Phosphoria (A through D members; Swanson, and others) (Ppl), "D" member is dark-gray to black carbonaceous and phosphatic mudstone with a few thin phosphate rock layers. Thickness 30-90 feet. "C" member is grayish-white, gray, or gray-brown cherty quartzite and cherty or sandy dolomite. Thickness 60-70 feet. "B" member is absent except in the southern part of the quadrangle where it comprises about 2 feet of cherty phosphate rock. "A" member is dominantly fine-grained dolomitic sandstone and sandy siltstone, light yellowish-tan and non-resistant with subordinate beds of vitreous quartzite Thickness 40-105 feet.

Lower Phosphoria is 265 feet thick at Kelley Gulch trench, 150 feet thick at Cave Gulch trench, and probably about 140 feet at Brown's Lake, 2 miles north of quadrangle.

Phosphoria formation undifferentiated (Pp), upper and lower Phosphoria both present but not separable.

EXPLANATION (Continued)

Pennsylvanian

Cq

Quadrant quartzite

Cream-white, light tan to pale gray massive- to thick-bedded vitreous quartzite, commonly cross-laminated, in places weathers dull rusty red. Very resistant, homogeneous unit, forms prominent, continuous ridges, characteristically conifer-mantled. Thickness about 650 feet.

Upper Mississippian

Ca

Amsden formation
(Pattern indicates area favorable for tungsten-molybdenum deposits)

Generally comprises two units of limestone and dolomite, alternating with two units of reddish or yellowish shale or sandstone. Characterized by rapid lateral variation in thickness and lithology; commonly poorly exposed; in many places mapped largely from float. At top is 65-135 feet of limestone and dolomite, generally varicolored and sandy, grading laterally to limy argillaceous sandstone, as at Brown's Lake 2 miles north of the quadrangle (T 3-4 S., R. 10 W). Underlain by 50-150 feet of shale, commonly reddish, grading laterally to very fine sandstone. Underlain by 50-250 feet of gray limestone and minor dolomite in beds up to three feet thick. At base is 60-130 feet of red or maroon shale apparently varying laterally to yellowish siltstone and very fine-grained sandstone. At Argenta the basal clastic unit and the lower carbonate unit appear to merge. Total thickness in Ermont thrust plate increases from 240 feet (sec. 21, T. 6 S., R. 10 W.) to about 550 feet near Apex damsite (sec. 23, T. 5 S., R. 10 W.), probably about 475 feet thick at Brown's Lake, 2 miles north of the quadrangle; and about 600 feet in higher western thrust plates. Near quartz monzonite bodies the impure limy sediments were converted to hornfels and locally the more nearly pure limestone to tactite. Adjacent to the major pluton the tactite is sparsely mineralized with powellite-rich scheelite and locally with molybdenite

Cmu / Cml / Cm

Mission Canyon limestone

Upper member (Cmu), light- to dark-gray limestone, commonly well-bedded but with a few thick massive ledges, generally fine- to medium-grained, locally dense, rarely coarse-grained; crinoidal debris common in coarser grained beds Minor amounts of light to dark fine-grained dolomitic limestone, generally thin-bedded, locally sandy or cherty. Thickness probably 525-650 feet. Larger apparent thicknesses are probably due to crumpling and faulting

Lower member (Cml), nearly white to gray coarse-grained massive crinoidal limestone Several units, one as much as 100 feet thick, of relatively fine-grained and thinly bedded limestone and dolomitic limestone similar to upper member Coarse-grained limestone makes up two-thirds or more of total thickness. Recrystallizes readily to massive white marble. Thickness variable; probably about 650-725 feet in Ermont thrust plate, about 475 feet in higher western plates. Larger apparent thicknesses are probably due to crumpling and faulting. Upper contact does not follow a single horizon due to poor exposures and alternating lithology.

Mission Canyon limestone undifferentiated (Cm).

Lower Mississippian

Cl

Lodgepole limestone

Thin-bedded fine-grained to dense, dark blue-gray limestone. Near base, beds are a few inches thick with shaly partings; in upper part beds are as much as a foot thick with no shaly partings. Thickness varies from about 750 to 950 feet; the greater thickness may be due to crumpling

Upper Devonian

Df

Three Forks shale

Rarely exposed, almost everywhere mapped by float. Upper half: thin beds of light-brown fissile soft shale near base, overlain by a few feet of fossiliferous limestone Upper part is platy siliceous shale, light brown to pale lavender, with thin black chert layers Lower half: tan and yellowish banded dolomitic siltstone and shale, some thin-bedded dolomite; 30 feet of light gray thick-bedded pure limestone at top. Thickness about 175 feet east of Ermont mine; probably thicker elsewhere.

Dju / Djl

Jefferson dolomite

Upper black dolomite member (Dju), black and brownish-black sugary-textured fetid dolomite, commonly thick-bedded to massive. A few beds of gray dolomite near base. In south, much interbedded light-colored limestone and limy dolomite in upper 150 feet. North of Rattlesnake Creek much of upper part of member converted to yellowish-weathering solution breccia of fine-grained calcite marble. At some localities in the southwest part of T. 5 S., R. 10 W., the entire member has been converted to calcite marble breccia. Thickness 550-600 feet; in south-central part of quadrangle locally thinned by non-deposition (?).

Lower gray dolomite member (Djl), gray, sugary-textured weakly mottled dolomite; locally sandy or conglomeratic at base. Present locally in southern part of quadrangle; absent elsewhere by non-deposition, maximum thickness 100 feet.

DISCONFORMITY

Upper Cambrian

Ꞓpd

Pilgrim (?) dolomite

Mostly thick-bedded, light-gray, sugary dolomite with several thinly laminated units locally containing distinctive small chert lenses. Formation commonly sandy near base. Includes 30 feet or less of Red Lion formation at top; variable laterally, comprises yellowish-gray dolomitic fine sandstone or gray sandy dolomite, and lenses of cross-bedded quartzite locally; Obolella sp. at one locality. Thickness 300 feet in NW¼ sec. 35, T. 6 S., R 11 W.; locally absent in south-central part of quadrangle by non-deposition.

Ꞓbc

Conglomerate and breccia

Conglomerate and sedimentary breccia with quartzite pebbles, boulders, and blocks. Largest measured block 16 feet long. Local deposit; present only in two restricted areas (secs. 1 and 24, T. 6 S., R. 11 W.). Maximum exposed thickness 150-200 feet; base faulted out at both localities.

BLOCK FAULTING, ANGULAR UNCONFORMITY

Middle Cambrian

Ꞓw

Wolsey shale

Gray-green soft fissile shale, interbedded red shale and glauconitic sandstone. Non-resistant unit, rarely exposed except where contact-metamorphosed. Maximum known thickness about 200 feet; locally absent by pre-Pilgrim erosion.

Ꞓf

Flathead quartzite

Pink or light-red cross-bedded vitreous quartzite, commonly thick-bedded. Middle part thin-bedded with shale partings. Resistant unit, forms prominent outcrops. Present locally in southern part of quadrangle; absent elsewhere, in part by pre-Pilgrim erosion. Thickness about 500 feet.

FAULTING (?), ANGULAR UNCONFORMITY

Later pre-Cambrian

$pꞒ_2$ / $pꞒ_1$ / $pꞒ_{1a}$

Belt series

Upper light-colored quartzite ($pꞒ_2$), white, very pale pink or pale bluish-gray thick-bedded quartzite, medium- to coarse-grained, commonly cross-laminated. Rocks in upper plate of Kelley thrust are more or less feldspathic throughout; commonly not feldspathic in lower plate. About 100 feet of dark gray shaly quartzite (s), at exposed top of member in upper plate; in lower plate shaly unit is 200-250 feet thick and occurs a few hundred feet below exposed top of member. Unit mapped only locally. In upper plate about 5,000-6,000 feet exposed in north-central portion of quadrangle; in lower plate at least several thousand feet exposed in faulted section.

Lower red member ($pꞒ_1$, $pꞒ_{1a}$), lower plate of Kelley thrust: Shale, argillaceous quartzite, and feldspathic quartzite ($pꞒ_1$), dominantly maroon or brick red, commonly green and gray. Ripple marks, mud cracks, and cross-bedding common. Exposed thickness probably in excess of 1,000 feet; base concealed. Upper plate of Kelley thrust: Arkosic quartzite ($pꞒ_{1a}$), cross-laminated, dominantly thick-bedded, medium- to coarse-grained, pink to deep rose red. Contact with overlying member gradational vertically over several hundred feet of beds. Northward-tapering wedge (?) deposit, probably more than 5,500 feet thick near southwest corner of quadrangle, thins to about 2000 feet in north-central portion, where the map unit includes about 800 feet of white quartzite and a few quartzite pebble-and cobble conglomerate lenses, lying below the arkosic wedge (?) and soled by the Kelley thrust.

Contact, showing dip
Solid where accurately located in the field; long-dashed where approximately located in the field; dotted where projected beneath concealing deposits; queried where inferred.

Gradational contact
Short-dashed; regardless of accuracy of location; dotted where concealed; queried where inferred.

Fault, showing dip
Solid where accurately located; dashed where approximately located; dotted where concealed; queried where inferred.

Thrust fault, showing dip
Saw-teeth indicate upper plate; T indicates upper plate where covered.

Anticline, showing trace of axial plane and plunge of axis; dashed where approximately located; dotted where concealed; queried where inferred.

Syncline, showing trace of axial plane and plunge of axis.

Overturned anticline

Overturned syncline

Bedding attitude; top determined by original sedimentary structures.

Bedding attitude; top indicated by stratigraphic and structural relations.

Bedding attitude; top inferred from uncertain data.

Overturned bedding attitudes

Strike of vertical beds; top indicated by number.

Horizontal beds

Spring

Note All streams, intermittent and perennial, shown with solid line

Wet meadow or bog

Ephemeral lake

Cave Gulch
LOT NO. 1257

Bulldozer trench in Phosphoria formation; name and lot number are designations of the Montana Phosphate Project of the Geological Survey (Swanson, R. W., and others, Stratigraphic Sections of the Phosphoria Formation in Montana, 1947-48: U. S. Geol. Survey Circular in press.)

Mine, showing index number

INDEX NUMBER	MINE	LOCATION 1/4	Section	T(S)	R(W)
1	Anaconda	NW	29	6	10
2	Argenta	SE	13	6	11
3	Brownell	NE	30	6	10
4	Carbonate	SW	18	6	10
5	Coolidge	SE	18	6	10
6	Cross	NE	11	6	11
7	Dexter	NW	17	6	10
8	Discovery	NE	11	6	11
9	Dutchman Mining Co.	NW	13	6	11
10	Ermont #2	SE	35	6	11
11	Ermont #19	NE	35	6	11
12	Ferdinand	SE	29	6	10
13	Gold Finch	SW	13	6	11
14	Golden Era	NE	13	6	11
15	Goldsmith	NE	30	6	10
16	Goodview	SW	18	6	10
17	Greenstone	SE	11	5	10
18	Ground Hog	SW	18	6	10
19	Indian Queen	SE	15	5	10
20	Iron Mountain	NE	30	6	10
21	Jack	SW	13	6	11
22	Jack Rabbit	NW	29	6	10
23	Legal Tender	SE	24	6	11
24	Mauldin (Louis Phillip)	NW	29	6	10
25	May Day	SE	7	6	10
26	Midnight	SE	13	6	11
27	Park	SW	1	6	11
28	Rena	NW	18	6	10
29	Rosemont	SE	8	6	10
30	Silver Rule	NE	16	6	11
31	Stimson	NW	14	6	11
32	Sylvia	SE	13	6	11
33	Tilden	NE	18	6	10
34	Tuscarora	NE	18	6	10
35	U. S. Treasurer	NE	21	5	10
36	Yellow Band	SE	2	6	11

Well drilled for oil
(Dry hole)

This map is a preliminary field map subject to corrections and has not been edited or reviewed for conformity with U. S. Geological Survey standards and nomenclature.

PRELIMINARY GEOLOGIC MAP
OF THE
N.W. ¼ OF THE WILLIS QUADRANGLE, BEAVERHEAD COUNTY, MONTANA

By W.B. Myers

Base map modified from manuscript photogrammetric map, U.S. Forest Service, 1946

19°
TRUE NORTH
MAGNETIC NORTH
APPROXIMATE MEAN DECLINATION, 1952

Scale 1:31,680
1000 0 1000 2000 3000 4000 5000 Feet
1 ½ 0 1 Mile

1952

Geology mapped 1946-1950

Montana #21