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

LOCATIONS, DESCRIPTIONS, DENSITIES, AND MAGNETIC SUSCEPTIBILTIES OF ROCK SAMPLES COLLECTED FOR ANALYSES OF GRAVITY AND AEROMAGNETIC ANOMALIES IN YELLOWSTONE NATIONAL PARK, WYOMING, IDAHO, AND MONTANA

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Open-file Report 98-247

1998

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INTRODUCTION

Centered beneath Yellowstone National Park in northwestern Wyoming and adjacent parts of Montana and Idaho (Fig. 1; USGS, 1972) is one of the world's largest active magmatic systems (Christiansen and Blank, 1972; Christiansen, 1982; 1984; in press). The well known hydrothermal activity of the national park is a direct expression of a magmatic system that has sustained activity of the Yellowstone Plateau volcanic field (Fig. 4) through latest Pliocene and Quaternary time, producing three cycles of voluminous rhyolitic eruptions that each climaxed with an exceedingly large ash-flow eruption and concomitant formation of a large collapse caldera. The first caldera-forming eruption (the Huckleberry Ridge Tuff) occurred at 2.0 Ma, the second (the Mesa Falls Tuff) at 1.3 Ma and the third (the Lava Creek Tuff) at 0.6 Ma; this third cycle formed the Yellowstone caldera that now occupies an area about 80 by 30 km across within the park (Fig. 1). Together the three voluminous ash-flow tuffs form a stratigraphic unit designated the Yellowstone Group. Rhyolitic lavas preceded and followed each caldera-forming eruption and partly filled each caldera. Basalts have erupted repeatedly surrounding the Yellowstone caldera and have partially flooded areas within the two older calderas.

Stratigraphically beneath the rocks of the Yellowstone Plateau volcanic field and surrounding the plateau itself are rocks ranging in age from Precambrian to Eocene (Figs. 2, 3). The regional basement consists principally of high-grade metamorphic rocks of Archaean age. That basement is overlain by predominantly marine sedimentary rocks of Paleozoic age that aggregate nearly 1,000 m in thickness and by Mesozoic strata nearly 3,000 m thick (Fig. 2; Ruppel, 1972; Love and Keefer, 1975). The early Mesozoic strata include both marine and continental rocks; the Cretaceous section comprises more than 2,500 m of sandstones and shales that are mostly of marine origin but include a continental volcanic-bearing orogenic-basin fill sequence at the top. The region was strongly deformed during the latest Cretaceous and earliest Tertiary Laramide orogeny. Predominantly intermediate volcanic and associated shallow-intrusive rocks were emplaced after the Laramide during the Eocene to form the Absaroka volcanic field (Fig. 3; Smedes and Prostka, 1972).

Most of the samples were collected in Yellowstone National Park, within the area of the gravity survey. Some samples of pre-Tertiary rocks, however, were collected just outside the park at Cinnabar Mountain (Fig. 1, numbers 11-26), where they are well exposed and easily accessible in a single measured section, and nearby at Yankee Jim Canyon (Fig. 1, number 27).

SAMPLES AND MEASUREMENTS

We collected a suite of 71 samples from 34 localities during the period July 23-26, 1992. Rock densities and magnetic susceptibilities were measured in September, 1992 by Cameron Ainsworth and H. W. Oliver at the U.S. Geological Survey in Menlo Park, Calif. Density measurements were made by weighing the rocks both in air and under water with a very accurate balance (Sartorius 1264 MP); densities were calculated by dividing the weight in air by the weight loss in water. Magnetic susceptibilities were measured with a susceptibility bridge (Scintrex SM05). This work was undertaken in order to help interpret the isostatic gravity map of Yellowstone National Park (Carle and others, 1990) and the aeromagnetic map (U.S. Geological Survey, 1973). Sample locations are shown by corresponding numbers in Figure 1, and approximate stratigraphic positions are indicated similarly in Figures 2-4. For convenient reference, the sample locations are also listed in Table 1, both by UTM coordinates and by latitude and longitude.

Table 1. Locations of samples collected for density and susceptibility measurements.

Locality	UTM (meters north)	UTM (meters east)	Latitude (degrees north)	Longitude (degrees east)
1	4892850	527530	44.1903	-110.6555
2	4894430	527220	44.2045	-110.6593
3	4898900	528160	44.2447	-110.6473
4	4928590	557840	44.5103	-110.2723
5	4926490	563840	44.4909	-110.1971
6	4923630	571690	44.4644	-110.0988
7	4928230	560160	44.5068	-110.2432
8	4973980	555500	44.9190	-110.2968
9	4975080	572000	44.9275	-110.0876
10	4973750	570290	44.9157	-110.1095
11	4992520	516490	45.0879	-110.7905
12	4992400	516330	45.0868	-110.7925
13	4992350	516290	45.0864	-110.7930
14	4992340	516230	45.0863	-110.7938
15	4992220	516180	45.0852	-110.7944
16	4992200	516140	45.0850	-110.7949
17	4992200	516080	45.0850	-110.7957
18	4992200	516020	45.0850	-110.7964
19	4991970	516560	45.0830	-110.7896
20	4991790	516760	45.0813	-110.7871
21	4992850	516480	45.0909	-110.7906
22	4992900	516520	45.0913	-110.7901
23	4993000	516410	45.0922	-110.7915
24	4993000	516520	45.0922	-110.7901
25	4993060	516430	45.0928	-110.7912
26	4993190	516660	45.0939	-110.7883
27	5001760	510510	45.1712	-110.8663
28	4951170	527680	44.7153	-110.6505
29	4945500	520400	44.6645	-110.7427
30	4963510	493390	44.8269	-111.0836
31	4982360	493900	44.9966	-111.0774
32	4981010	494000	44.9845	-111.0761
33	4961080	491520	44.8050	-111.1072
34	4942050	510770	44.6337	-110.8642

SAMPLE DESCRIPTIONS AND LOCATIONS

1. **Lewis Canyon Rhyolite (Pleistocene).**
Lat. 44.1903°, Long. -110.6555°
Collected from the southernmost roadside overlook of Lewis Canyon (Figs 1, 4). This rhyolite, here a single lava flow about 930,000 years old, partly fills the Snake River segment of the first-cycle caldera of the Yellowstone Plateau volcanic field (Christiansen and Blank, 1972; USGS, 1972). The flow is at least 100 m thick, but, as its base is not seen, it could be much thicker.

Sample	Description	DENSITY (g/cm^3)	MAG. SUSC. (10^{-3} SI)
1A.	Crystallized rhyolitic lava with prominent phenocrysts of plagioclase and quartz. Typical of 85-90% of the outcrop.	2.28	5.04
1B.	Similar to 1A.	2.42	7.27
1C.	Similar to 1A and 1B but with abundant lithophysae (subspherical cavities lined with vapor-phase minerals). Represents the lithology of about 10-15% of the outcrop.	2.33	7.71

2. **Lava Creek Tuff, Yellowstone Group (Pleistocene).**
Lat. 44.2045°, Long. -110.6593°
Collected from member B of the Lava Creek Tuff about midway from south to north along the west rim of Lewis Canyon (Figs. 1, 4). This densely welded tuff is the typical extracaldera lithology of this widespread 600,000-year-old caldera-forming unit of the third volcanic cycle of the Yellowstone Plateau volcanic field (Christiansen and Blank, 1972; Christiansen, 1984). Here the unit is about 60 m thick, but elsewhere it exceeds 550 m in thickness.

Sample	Description	DENSITY (g/cm^3)	MAG. SUSC. (10^{-3} SI)
2A.	Contains only sparse welded pumice and represents about 60% of the local lithology of the unit.	2.36	5.80
2B.	Similar to 2A but with abundant welded pumice and lithophysal crystallization in secondary open spaces, representing about 40% of the local lithology of the unit.	2.32	4.32

3. **Central Plateau Member of Plateau Rhyolite (Pleistocene); Pitchstone Plateau flow.**
Lat. 44.2447°, Long. -110.6473°
Collected from near the east end of the Pitchstone Plateau Trail (Figs. 1, 4). This rhyolite flow is about 70,000 years old and was erupted within the 600-ka Yellowstone caldera where it overlaps the 2.0-Ma first-cycle caldera (Christiansen and Blank, 1972; USGS, 1972). The flow is as much as 350 m thick and is but one of a sequence of similar flows of unknown total thickness within the Yellowstone caldera.

Sample	Description	DENSITY (g/cm^3)	MAG. SUSC. (10^{-3} SI)
3A.	Crystallized rhyolite with prominent phenocrysts of quartz and sanidine and having the lowest porosity of the 3 collected here.	2.33	3.30
3B.	Similar to 3A but contains lithophysae.	2.30	4.08
3C.	Similar to 3B.	2.13	1.64

4. **Langford Formation, Absaroka Volcanic Supergroup (Eocene).**
Lat. 44.5103°, Long. -110.2723°
Collected from the east end of the parking area at Lake Butte (Figs. 1, 3). This unit, mainly volcanic breccia, underlies much of southeastern Yellowstone National Park and is as much as 600 m thick (Smedes and Prostka, 1972; USGS, 1972).

4A. Fragments of pyroxene andesite and dacite(?) in a silt-sized matrix of andesitic composition. Sample appears to have been affected slightly by contact metamorphism from nearby intrusion of diorite or hypabyssal andesite and, thus, may be slightly denser than is typical for the unit.	2.41	18.6
4B. Similar to 4A, collected from about 15 m away.	2.51	8.5

5. **Stock intrusive into Langford Formation, Absaroka Volcanic Supergroup (Eocene).**
Lat. 44.4909°, Long. -110.1971°
Collected from the westernmost road cut above Clear Creek (Figs. 1, 3; Smedes and Prostka, 1972; USGS, 1972). This intrusion probably is the source of a gravity high of +34 mGal east of Yellowstone Lake.

5A. Fine-grained medium-gray hornblende-biotite diorite with sparse phenocrysts of hornblende up to 4-5 mm. Represents the most abundant lithology at this locality.	2.69	42.6
5B. Leucocratic hornblende diorite (color index about half that of 5A).	2.56	27.1
5C. Hornblende diorite porphyry with aphanitic groundmass and abundant large phenocrysts of hornblende to 1 cm and some plagioclase to 2 mm; sparse olivine to 4 mm. Rock contains numerous inclusions of varied rock fragments of 5-30 mm. Probably represents <5% of this outcrop.	2.26	36.1

6. **Trout Peak Trachyandesite, Absaroka Volcanic Supergroup (Eocene).**
Lat. 44.4644°, Long. -110.0988°
Collected along the roadside about 5 km east of Sylvan Pass (Figs. 1, 3). Consists of lava flows and breccias about 300 m thick (Smedes and Prostka, 1972; USGS, 1972).

6A. Dark lava with phenocrysts of augite up to 6 mm, plagioclase to 3 mm, (commonly saussuritized), and olivine to 3 mm (iddingsitized). This is the most common, characteristic rock type of the outcrop (about 70%).	2.73	12.3
6B. Similar to 6A but with weathered surfaces; represents <2% of the outcrop.	2.70	12.5
6C. Similar to 6A but vesicular; represents about 10 % of the outcrop. Two separate pieces of the sample were measured.	2.58 2.56	33.7 34.1

7. **Langford Formation, Absaroka Volcanic Supergroup (Eocene).**
Lat. 44.5068°, Long. -110.2432°
Collected 1 km east of Lake Butte (Figs. 1, 3). This andesitic mudflow breccia is the predominant lithology of the Absaroka Range in southeastern Yellowstone National Park, where it is as much as 600 m thick (Smedes and Prostka, 1972; USGS, 1972). The rock here is more typical of the unit than that at locality 4, which is in an intrusive-contact aureole.

7A.	Andesitic lava fragments in a silt-sized matrix.	2.32	8.00
	Two separate pieces of the sample were measured.	2.33	8.74
7B.	Similar to 7A.	2.41	9.15

8. **Granitic gneiss (Precambrian).**
Lat. 44.9190°, Long. -110.2968°
Collected in Lamar Canyon near its west end (Figs. 1, 2; Ruppel, 1972). A similar basement lithology is widely exposed in the Beartooth and Absaroka Ranges to the north and northeast.

8A.	Biotite granitic gneiss with almandine-rich garnet and epidote.	2.73	25.3
8B.	Similar to 8A, from another part of the same 1.5-m block.	2.69	25.3

9. **Lamar River Formation, Absaroka Volcanic Supergroup (Eocene).**
Lat. 44.9275°, Long. -110.0876°
Collected in Icebox Canyon (Figs. 1, 3). This andesitic mudflow breccia underlies much of the Absaroka Range in northeastern Yellowstone National Park, where it commonly is 300-700 m thick (Smedes and Prostka, 1972; USGS, 1972).

9A.	Fragments of sparsely porphyritic andesite in an andesitic mudstone matrix. The largest blocks are up to 5 m, but many fragments are in the range 1-5 cm.	2.45	7.46
9B.	Similar to 9A.	2.49	7.25
9C.	Similar to 9A and 9B.	2.43	5.80

10. **Madison Group (Mississippian).**
Lat. 44.9157°, Long. -110.1095°
Collected at Round Prairie (Figs. 1, 2). This mainly calcitic limestone is an important regional aquifer and at about 360 m is one of the thickest limestones of the Yellowstone Paleozoic section (Ruppel, 1972; Love and Keefer, 1975).

10A.	Aphanitic, nearly massive limestone.	2.69	0.01
10B.	Similar to 10A.	2.66	0.02
10C.	Similar to 10A and 10B.	2.68	0.03

Samples 11-26 are from the Cinnabar Mountain stratigraphic section, located about 8 km north-northwest of Gardiner, Montana (Figs. 1, 2) ; most of the section was measured by Fraser and others (1969, p. 89-97).

11. **Kootenai Formation (Lower Cretaceous)** Lat. 45.0879°, Long. -110.7905° Following the nomenclature of Ruppel (1972). Designated as the lower sandstone and conglomerate member of the Cloverly Formation by Fraser and others (1969). The sample is a fine-grained quartzitic sandstone. Thickness 10 m.	2.57	0.04
12. **Lower sandstone member of Thermopolis Shale (Lower Cretaceous)** Lat. 45.0868°, Long. -110.7925° Following the nomenclature of Ruppel (1972). Designated as the upper sandstone member of the Cloverly Formation by Fraser and others (1969). The sample is a medium-grained cross-laminated quartzitic sandstone. Thickness 27 m.	2.57	0.05
13. **Middle shale member of Thermopolis Shale (Lower Cretaceous)** Lat. 45.0864°, Long. -110.7930° Following the nomenclature of Ruppel (1972). Designated as the shale member of the Thermopolis Shale of Fraser and others (1969). Contains fossil tracks. Thickness of the unit 85 m, of which about 25% consists of siltstones and sandstones similar to these samples.		
13A. Thin-bedded gray pyritic siltstone intercalated in the predominant shales of the member.	2.59	0.08
13B. Similar to 13A, from the same outcrop.	2.57	0.07
13C. Similar to 13A and 13B, from the same outcrop.	2.61	0.08
14. **Middle shale member of Thermopolis Shale (Lower Cretaceous)** Lat. 45.0863°, Long. -110.7938° Following the nomenclature of Ruppel (1972). Designated as the shale member of the Thermopolis Shale by Fraser and others (1969). Conchoidally fractured black shale or mudstone that is the predominant lithology of the member. Thickness of the unit 85 m, of which about 75% consists of shales similar to the sample.	2.48	0.18
15. **Upper sandstone member of Thermopolis Shale (Lower Cretaceous)** Lat. 45.0852°, Long. -110.7944° Following the nomenclature of Ruppel (1972). Designated as the Muddy Sandstone Member of the Thermopolis Shale by Fraser and others (1969). Medium- to coarse-grained lithic arkosic sandstone with about 20% of dark rock and mineral grains that give the lithology a distinct "salt and pepper" appearance. Calcareous cement. Thickness 35 m.	2.42	0.05
16. **Mowry Shale (Lower Cretaceous)** Lat. 45.0850°, Long. -110.7949° Following the nomenclature of Ruppel (1972) and Fraser and others (1969). Black thin-bedded siliceous shale with blocky fracture. Thickness 99 m.	2.57	0.12

17. **Frontier Sandstone (Upper Cretaceous)** Lat. 45.0850°, Long. -110.7957° Following the nomenclature of Ruppel (1972). Designated as the lower sandstone Member of the Frontier Formation by Fraser and others (1969). Sample, from near the stratigraphic top of the formation, is medium-grained , thick-bedded calcareous sandstone of lithic "salt and pepper" type. Thickness 17 m.	2.52	0.07
18. **Cody Shale (Upper Cretaceous)** Lat. 45.0850°, Long. -110.7964° Following the nomenclature of Ruppel (1972). The rocks of this locality were included as the middle shale member of the Frontier Formation by Fraser and others (1969). Collected near base of unit. Crumbly dark gray to black fissile shale. Thickness of the formation about 470 m.	2.47	0.13
19. **Telegraph Creek Formation (Upper Cretaceous)** Lat. 45.0830°, Long. -110.7896° Following the nomenclature of Ruppel (1972) and Fraser and others (1969). Thickness about 90 m.		
19A. Well sorted arkosic siltstone	2.64	0.09
19B. Similar to 19A.	2.63	0.10
19C. Similar to 19A and 19B.	2.60	0.11
20. **Eagle Sandstone (Upper Cretaceous)** Lat. 45.0813°, Long. -110.7871° Following the nomenclature of Ruppel (1972) and Fraser and others (1969). Medium-grained biotitic sandstone, ranging from medium- to thick-bedded. Thickness about 240 m.	2.58	1.00
21. **Swift Formation, Ellis Group (Jurassic)** Lat. 45.0909°, Long. -110.7906° Following the nomenclature of Ruppel (1972) and Fraser and others (1969). Sandy limestone. Some beds, including that from which the sample was taken, are highly fossiliferous, with conspicuous pectins. Thickness 20 m.	2.66	0.08
22. **Augite-diorite porphyry dike (Eocene?).** Lat. 45.0913°, Long. -110.7901° This intrusion is only about 12 m thick but stands out from the surrounding sedimentary rocks with about 35 m of relief. This is either a dike of Eocene age or a sill of latest Cretaceous age.	2.64	7.38
23. **Woodside Formation (Triassic)** Lat. 45.0992°, Long. -110.7915° Following the nomenclature of Ruppel (1972). Discussed as the lower part of the Chugwater Formation by Fraser and others (1969). This unit forms the conspicuous red stripe of Devils Slide on the east side of Cinnabar Mountain. It consists predominantly of red calcareous siltstone, very thin-bedded and laminated, with a few very thin limestone interbeds. Thickness about 12 m.	2.70	0.19

24. **Shedhorn Sandstone (Permian)** Lat. 45.0922°, Long. -110.7901° Following the nomenclature of Ruppel (1972). Designated as the Park City Formation by Fraser and others (1969). Highly fractured dark crystalline limestone in beds 40-50 cm thick, weathering to light gray. Elsewhere this stratigraphic interval is occupied by varied sandstones, cherts, and phosphorites. Thickness 29 m.	2.67	0.06
25. **Quadrant Sandstone (Pennsylvanian)** Lat. 45.0928°, Long. -110.7912° Following the nomenclature of Ruppel (1972). Designated as the Quadrant Quartzite by Fraser and others (1969). Fine-grained thick-bedded light- to medium-gray quartzite. Thickness 54 m.	2.55	0.04
26. **Mission Canyon Limestone, Madison Group (Mississippian)** Lat. 45.0939°, Long. -110.7883° Following the nomenclature of Ruppel (1972). Discussed as the Madison Limestone by Fraser and others (1969). Collected from the top 15 m of the unit. Massive light-gray limestone. Thickness about 250 m. Two separate pieces of the sample were measured.	2.42 2.32	0.01 0.02
Sample 26 is the last of the samples collected from the Cinnabar Mountain section.		
27. **Gneiss (Precambrian)**. Lat. 45.1712°, Long. -110.8663° Collected at the head of Yankee Jim Canyon, about 18 km north of Gardiner, Montana (Figs. 1, 2). This is a common lithology in the area of a surrounding gravity high.		
27A. Well foliated biotite-microcline-plagioclase-quartz gneiss.	2.72	0.22
27B. Similar to 27A.	2.70	0.20
27C. Similar to 27A and 27B.	2.72	0.16
28. **Lava Creek Tuff, Yellowstone Group (Pleistocene)**. Lat. 44.7153°, Long. -110.6505° Collected along the Virginia Cascade loop road, about 5 km east of Norris Junction (Figs. 1, 4). This is the caldera-forming ash-flow tuff of 600,000-year age (Christiansen and Blank, 1972), which locally is >100 m thick. The samples were collected from the bottom 10 m of member B, near the middle of the local section.		
28A. Porphyritic welded rhyolitic tuff, with phenocrysts of quartz, sanidine, and sodic oligoclase.	2.40	4.61
28B. Similar to 28A.	2.27	5.31
28C. Similar to 28A and 28B.	2.36	4.50

29. **Central Plateau Member, Plateau Rhyolite (Pleistocene); Gibbon River flow.**
Lat. 44.6645°, Long. -110.7427°
Collected on the east side of Gibbon Canyon about 3 km south of Beryl Spring (Figs. 1, 4; Christiansen and Blank, 1972; USGS, 1972). This flow, of about 90 ka, is the southernmost in a line of rhyolitic lava flows and domes erupted between the Norris Geyser Basin area and Mammoth Hot Springs (Fig. 1). It is about 120 m thick.

29A. Rock from crystalline interior of the flow. Contains abundant lithophysae. Two separate pieces of the sample were measured.	2.33 2.33	3.65 3.60
29B. Similar in composition to 29A but a dense black vitrophyre from the exterior of the flow.	2.35	3.10

30. **Schist (Precambrian).**
Lat. 44.8269°, Long. -111.0836°
Collected on the west side of Grayling Creek, along U.S. Highway 191, about 6 km north of the 191-287 intersection (Figs. 1, 2; see Witkind, 1969). This is the basement lithology of the northwestern part of Yellowstone National Park, here underlying the basal contact of the Huckleberry Ridge Tuff.

30A. Quartz-biotite schist.	2.70	0.25
30B. Similar to 30A.	2.73	0.33
30C. Similar to 30A and 30B but somewhat more felsic and less schistose.	2.73	0.26
30D. Finer-grained, darker, and denser than 30A-30C. Color index about 80.	3.00	0.70

31. **Dioritic stock or laccolith (Eocene)**
Lat. 44.9966°, Long. -111.0774°
Intruded into limestone of the Madison Group. Collected along the upper Gallatin River about 2 km upstream from the intersection of Specimen Creek (Figs. 1, 3). This stock is near the center of a 40-mGal gravity high. Mapped as the Gallatin River laccolith by Witkind (1969).

31A. Hornblende-diorite porphyry with abundant hornblende and plagioclase phenocrysts in an aphanitic matrix. Hornblende phenocrysts are up to 3 cm. The diorite contains abundant metamorphic inclusions, including hornblende-rich inclusions up to 6 cm. Epidote is disseminated throughout.	2.76	42.2
31B. Similar to 31A.	2.72	32.4
31C. Similar to 31A and 31B.	2.74	37.8

32. **Lodgepole Limestone, Madison Group (Mississippian).**
Lat. 44.9845°, Long. -111.0761°
Collected from the east side of the Gallatin River Valley across from Snowslide Creek (Figs. 1, 2; Ruppel, 1972; Witkind, 1969). Thickness about 120 m.

32A. Dark-gray limestone with quartz-siltstone laminae constituting about 5% of the rock.	2.67	0.02

32B. Brecciated limestone with recrystallized coarse calcite cement.	2.71	0.04
32C. Aphanitic limestone.	2.72	0.07

33. **Huckleberry Ridge Tuff, Yellowstone Group (Pliocene).**
Lat. 44.8050°, Long. -111.1072°
Collected along the west side of Grayling Creek about 3 km north of the junction of U.S. Highways 191 and 287 (Figs. 1, 4). This is the 2.0-Ma caldera-forming rhyolitic ash-flow tuff of the first volcanic cycle (Christiansen and Blank, 1972). Thickness of the Huckleberry Ridge Tuff at this locality is about 150 m, but elsewhere it is >300 m.

33A. Welded rhyolitic ash-flow tuff with moderately abundant (about 25%) phenocrysts of quartz, plagioclase, and sanidine, generally about 1-2 mm. Contains some lenses of white welded pumice to 4 cm and lithic inclusions, mainly of Precambrian metamorphic rocks. Limonitic staining is pervasive.	2.31	4.39
33B. Similar to 33A.	2.35	3.43
33C. Similar to 33A and 33B.	2.31	5.00

34. **Central Plateau Member, Plateau Rhyolite (Pleistocene); Nez Perce Creek flow.**
Lat. 44.6337°, Long. -110.8642°
Collected on the east side of Firehole Canyon about 3 km south of Madison Junction (Figs. 1, 4; see Christiansen and Blank, 1972; USGS, 1972). This is one flow, about 90 m thick, in the much thicker sequence that fills much of the Yellowstone caldera; the flow is lithologically typical of those lavas in general.

34A. Crystallized interior of rhyolite flow, with some lithophysae. Moderately abundant phenocrysts of quartz and sanidine. Together, samples 34A and 34B probably represent about 80% of the volume of the flow.	2.26	4.16
34B. Similar to 34A but darker and with pervasive irregular fracture surfaces.	2.34	3.49
34C. Welded glassy flow breccia with black glass lenses in a reddish-brown glass matrix. Composition like that of the crystallized samples. Together, samples 34C-34E probably represent about 20% of the volume of the flow.	2.21	1.05
34D. Vitrophyre with spherulites and lithophysae. Two separate pieces of the sample were measured.	2.27 2.26	5.90 6.24
34E. Partly hydrated vitrophyre of composition similar to samples 34A-C. Two separate pieces of the sample were measured.	2.02 2.24	1.18 0.70

SUMMARY

On the basis of the foregoing measurements, average densities were estimated for several packages of rock units that might be useful in modeling the gravity field of the Yellowstone Plateau region. For this purpose, the following units were considered: Precambrian metamorphic basement rocks, Paleozoic sedimentary rocks, Mesozoic sedimentary rocks, early Tertiary volcanic and volcaniclastic rocks, early Tertiary intrusive rocks, ash-flow tuffs and interlayered rhyolites and basalts of the Yellowstone Plateau volcanic field, and postcollapse volcanic rocks and sediments within the Yellowstone caldera. Average densities were estimated for each of these gross units, weighting them according to our estimated percentages of various lithologies represented in each gross unit. On that basis, we estimate the following average densities :

Aggregate unit	**Density (g/cm^3)**
Pleistocene postcollapse rocks and deposits in the Yellowstone caldera	2.28
Pleistocene and Pliocene ash-flow tuffs and interlayered volcanic rocks	2.32
Tertiary volcanic and volcaniclastic rocks	2.49
Tertiary intrusive rocks	2.62
Mesozoic sedimentary rocks	2.54
Paleozoic sedimentary rocks	2.65
Precambrian metamorphic rocks	2.72

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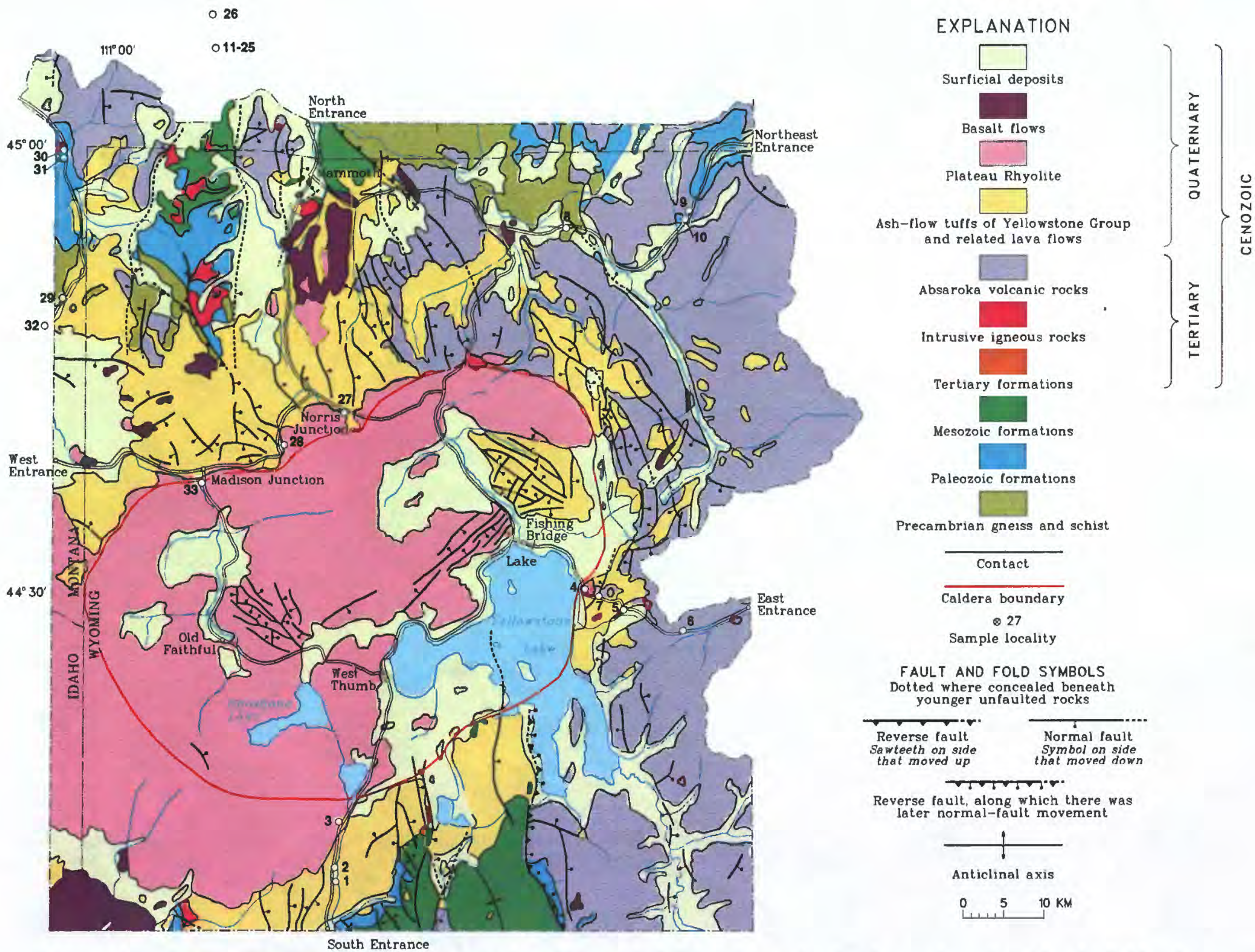


Figure 1. Generalized geologic map of Yellowstone National Park. Numerals indicate approximate locations by sample number. More detailed locations are given in the text and Table 1. Yellowstone caldera located by red line. Modified from Keefer (1971, Pl. 1).

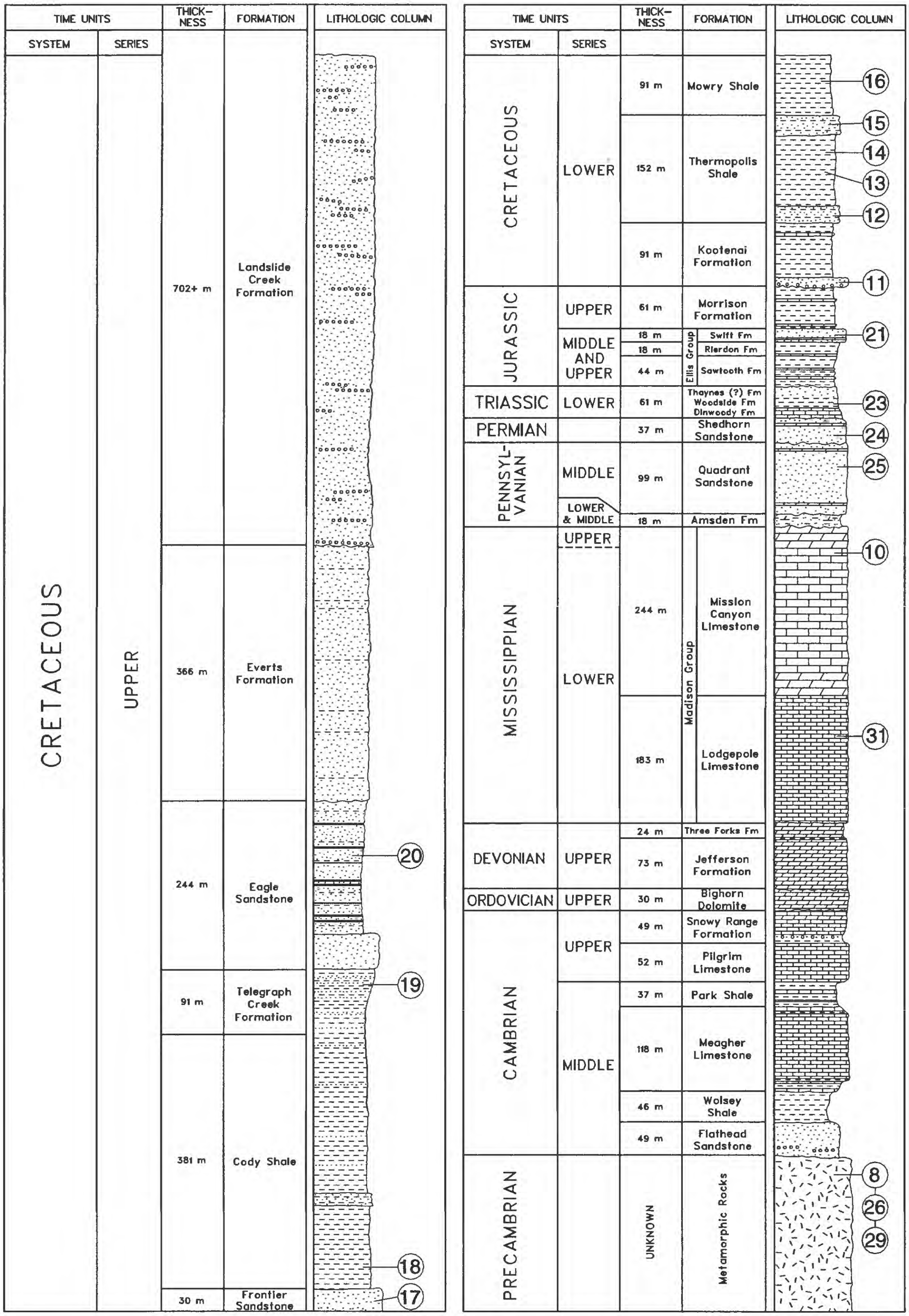
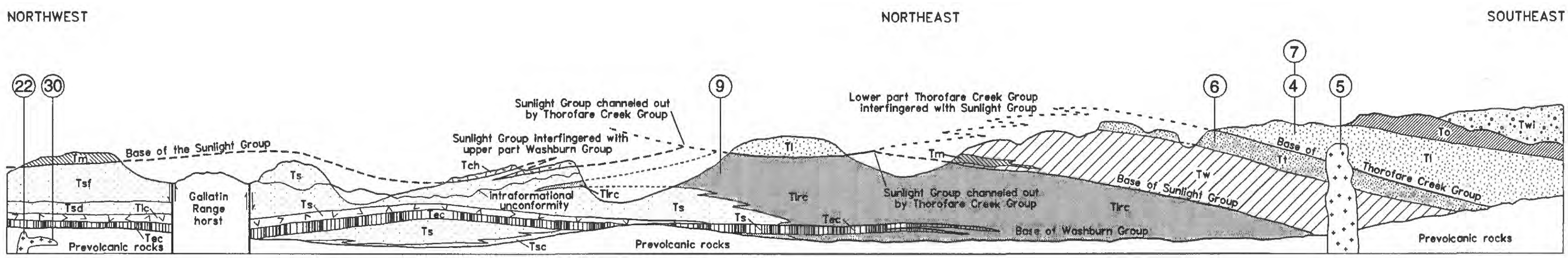


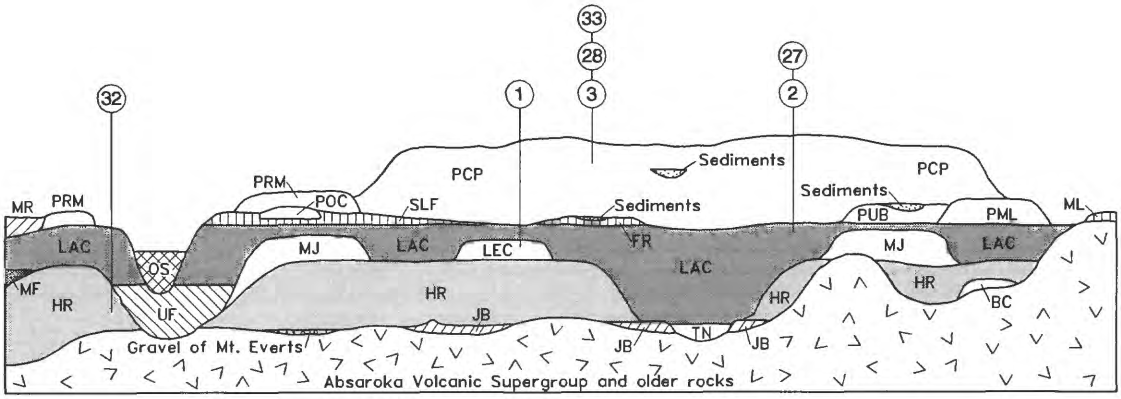
Figure 2. Columnar section of pre-Tertiary stratigraphic units of Yellowstone National Park and vicinity. Units shown are those for the northern part of the park, based upon data in Ruppel (1972). A slightly different stratigraphy in the southern part of the park has been described by Love and Keefer (1972), but the physical properties of major lithologic units are similar. Numerals indicate approximate stratigraphic positions of samples.



EXPLANATION

Twi	Wiggins Formation	Tlrc	Lamar River and Cathedral Cliffs Formation
To	Two Ocean Formation	Ts	Sepulcher Formation, undivided
Tl	Langford Formation	Tsf	Fortress Mountain Member
Tt	Trout Peak Trachyandesite	Tsd	Daly Creek Member
Tw	Wapiti Formation	Tlc	Lost Creek Tuff Member
Tm	Mount Wallace Formation	Tec	Elk Creek Basalt Member
Tch	Crescent Hill Basalt	Tsc	Conglomerate Facies

Figure 3. Diagrammatic section of stratigraphic units in the Eocene Absaroka volcanic field of Yellowstone National Park and vicinity, modified after Smedes and Prostka (1972). Numerals indicate approximate stratigraphic positions of samples.



EXPLANATION

Third volcanic cycle	PRM	Roaring Mountain Member	Plateau Rhyolite
	PCP	Central Plateau Member	
	POC	Obsidian Creek Member	
	PUB	Upper Basin Member	
	PML	Mallard Lake Member	
	OS	Osprey Basalt	
	MR	Madison River Basalt	
	SLF	Swan Lake Flat Basalt	
	FR	Falls River Basalt	
	ML	Basalt of Mariposa Lake	
	LAC	Lava Creek Tuff	
	UF	Undine Falls Basalt	
	MJ	Mount Jackson Rhyolite	
Second volcanic cycle	MF	Mesa Falls Tuff	
First volcanic cycle	TN	Sediments and basalts of The Narrows	
	LEC	Lewis Canyon Rhyolite	
	HR	Huckleberry Ridge Tuff	
	BC	Rhyolite of Broad Creek	
	JB	Junction Butte Basalt	

Figure 4. Diagrammatic section of stratigraphic units in the late Pliocene and Quaternary Yellowstone Plateau volcanic field of Yellowstone National Park and vicinity, modified after Christiansen and Blank (1972). Numerals indicate approximate stratigraphic positions of samples.