INDEX MAP SHOWING LOCATION OF BLACK HILLS NATIONAL FOREST

Base from U.S. Geological Survey
Gillette, 1955 (revised 1975); Hot Springs, 1955 (revised 1978);
Newcastle, 1955 (revised 1975); Rapid City, 1953 (revised 1978)

SCALE 1:250 000

CONTOUR INTERVAL 200 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929
1986 MAGNETIC DECLINATION FOR THIS SHEET VARIES FROM 11°00' EASTERLY IN THE SOUTHEASTERN CORNER TO 12°30' EASTERLY IN THE NORTHWESTERN CORNER. MEAN ANNUAL CHANGE IS 0°08.5' WESTERLY.

MAP LOCATION

Geology compiled by Anna Burack Wilson, Ed DeWitt, and David Buscher, 1985

GEOLOGIC MAP OF THE BLACK HILLS NATIONAL FOREST AND ADJACENT AREA, SOUTH DAKOTA AND WYOMING

CORRELATION OF MAP UNITS

DESCRIPTION OF MAP UNITS

Qu — **Unconsolidated deposits (Quaternary)**—Alluvium and colluvium. Minor deposits, all terrace gravels, and landslide deposits not shown. Thickness 0-150 ft

Tw — **White River Group (Oligocene)**—Tuffaceous claystone and clay containing minor limestone lenses. Locally thick limestone near Rockerville. Group divided into Brule (top) and Chadron (base) Formations. Some Brule present east of the Black Hills. Map unit includes Miocene Ogallala Formation in the Bear Lodge Mountains. Thickness 0-300 ft

Kn — **Nepheline-normative intrusive rocks (Eocene and Paleocene)**—Stocks, sills, dikes, and laccoliths of phonolite, trachyphonolite, some trachyte, lamprophyre, pyroxenite, diorite, vogesite, carbonatite, foyaite, feldspathoidal porphyry, and miscellaneous mafic and basic intrusive rocks as named by previous authors in the northern Black Hills. Eocene-Paleocene age assignment based on geochronology from Bassett (1961), McDowell (1971), Hill, Izett, and Naeser (1975), and Staatz (1983)

Kq — **Quartz-normative intrusive rocks (Eocene and Paleocene)**—Stocks, sills, dikes, laccoliths, and minor volcanic pipes composed of rhyolite, latite, quartz latite, andesite, feldspar porphyry, quartz porphyry, granodiorite, some trachyte, and miscellaneous siliceous intrusive rocks as named by previous authors in the northern Black Hills. Eocene-Paleocene age assignment based on geochronology by Mukherjee (1968), McDowell (1971), Redden and others (1983), and Staatz (1983)

Ki — **Lance Formation (Upper Cretaceous)**—Shale interbedded with channel sandstone and minor lignite lenses. Exposed in western Black Hills, Wyo. Includes the basal part of the Tullock Member of the Fort Union Formation in Wyoming. Thickness 2,000-3,400 ft

Kth — **Fox Hills Sandstone (Upper Cretaceous)**—Sandstone and shale. Thickness 125-200 ft

Kp — **Pierre Shale (Upper Cretaceous)**—Black shale containing minor limestone lenses and large concretions. Age in Wyoming as reported by Love and Christiansen (1985) is 72-78 Ma. Thickness 1,200-2,700 ft

Kng — **Niobrara Formation, Carlile Shale, and Greenhorn Limestone (Upper Cretaceous)**

Niobrara Formation—Marl and shale. Age in Wyoming as reported by Love and Christiansen (1985) is about 83 Ma. Thickness 80-300 ft

Carlile Shale—Sandy shale containing large concretions. Thickness 345-620 ft

Greenhorn Limestone—Limestone and limy sandstone. Thickness 225-400 ft

Kbs — **Belle Fourche Shale (Upper Cretaceous), and Mowry Shale, Newcastle Sandstone, and Skull Creek Shale (Lower Cretaceous)**—Shown in eastern Black Hills

Kb — **Belle Fourche Shale (Upper Cretaceous)**—Bentonitic shale containing minor limestone lenses and large concretions. Thickness 150-850 ft

Kms — **Mowry Shale, Newcastle Sandstone, and Skull Creek Shale (Lower Cretaceous)**

Mowry Shale—Siliceous shale containing thin bentonite layers. Age in Wyoming as reported by Love and Christiansen (1985) is 94-98 Ma. Thickness 125-230 ft

Newcastle Sandstone—Sandstone and siltstone containing beds of bentonite and lignite. Thickness 0-100 ft

Skull Creek Shale—Black shale. Thickness 150-270 ft

KPim — **Inyan Kara Group (Lower Cretaceous), Morrison Formation and Unkpapa Sandstone (Upper Jurassic), Sundance Formation (Upper and Middle Jurassic), Gypsum Spring Formation (Middle Jurassic), Spearfish Formation (Triassic and Permian), and Minnekahta Limestone (Lower Permian)**—Shown at Bear Butte

KJim — **Inyan Kara Group (Lower Cretaceous), and Morrison Formation and Unkpapa Sandstone (Upper Jurassic)**

Inyan Kara Group

Fall River Sandstone—Sandstone and minor siltstone. Thickness 100-200 ft

Lakota Formation—Claystone and sandstone locally interbedded with limestone and lignite lenses. Thickness 35-700 ft

Morrison Formation—Siliceous claystone and shale. Thickness 0-150 ft

Unkpapa Sandstone—Sandstone. Thickness 0-275 ft

JPsm — **Sundance Formation (Upper and Middle Jurassic), Gypsum Spring Formation (Middle Jurassic), Spearfish Formation (Triassic and Permian), Minnekahta Limestone and Opeche Shale (Lower Permian), and Minnelusa Formation (Lower Permian and Pennsylvanian)**—Shown at Bear Butte

Jsg — **Sundance Formation (Upper and Middle Jurassic) and Gypsum Spring Formation (Middle Jurassic)**

Sundance Formation—Glauconitic sandstone and shale. Thickness 250-475 ft

Gypsum Spring Formation—Massive gypsum and minor claystone. Thickness 0-125 ft

TRs — **Spearfish Formation (Triassic and Permian)**—Shale, siltstone, gypsum, and minor limestone. Thickness 325-900 ft

Pmo — **Minnekahta Limestone and Opeche Shale (Lower Permian)**

Minnekahta Limestone—Slabby limestone. Thickness 35-50 ft

Opeche Shale—Silty shale. Thickness 25-150 ft

PPm — **Minnelusa Formation (Lower Permian and Pennsylvanian)**—Sandstone, solution breccia (anhydrite in subsurface), limestone, and shale. Thickness 400 to >1,050 ft

MEpd — **Pahasapa Limestone (Lower Mississippian), Englewood Formation (Lower Mississippian and Upper Devonian), Whitewood Dolomite (Upper Ordovician), Winnipeg Formation (Middle Ordovician), and Deadwood Formation (Lower Ordovician and Upper Cambrian)**—Shown in northern Black Hills

MDpe — **Pahasapa Limestone (Lower Mississippian) and Englewood Formation (Lower Mississippian and Upper Devonian)**

Pahasapa Limestone—Cavernous dolomitic limestone. Thickness 300-630 ft

Englewood Formation—Dolomitic limestone. Thickness 35-60 ft

OEwd — **Whitewood Dolomite (Upper Ordovician), Winnipeg Formation (Middle Ordovician), and Deadwood Formation (Lower Ordovician and Upper Cambrian)**

Whitewood Dolomite—Dolomite. Thickness 0-150 ft

Winnipeg Formation—Shale and siltstone. Thickness 0-110 ft

Deadwood Formation—Sandstone, shale, and limestone. Thickness 4-700 ft

Xh — **Harney Peak Granite (Early Proterozoic)**—Coarse-grained to pegmatitic muscovite granite and pegmatite containing accessory garnet, biotite, and tourmaline. Age (recalculated using decay constants recommended by Steiger and Jaeger, 1977) from Rb-Sr whole-rock isochron is 1,697±33 Ma (Riley, 1970)

Xsh — **Metasedimentary rocks (Early Proterozoic)**—Phyllite, slate, and mica schist. Protoliths include shale, carbonaceous shale, and minor siltstone. Includes the Grizzly Formation (Dodge, 1942), Swede Gulch Formation (Bayley, 1972c), part of the Oreville Formation (Ratté and Wayland, 1969), and a large area of rocks in the core of the Black Hills

Xms — **Metasedimentary rocks (Early Proterozoic)**—Muscovite schist, muscovite phyllite. Protoliths include aluminous, tuffaceous shale (now magnetite-ilmenite-rich) and thin, manganiferous chert-carbonate beds. Includes part of the Oreville Formation

Xgw — **Metagraywacke (Early Proterozoic)**—Siliceous mica schist and impure quartzite. Protoliths are turbidite deposits that include graywacke and mixed graywacke and shale. Includes the Roubaix Formation (Bayley, 1972b), Mayo Formation and Bugtown Formation (Redden, 1963), and part of the Oreville Formation

Xbs — **Metasedimentary rocks (Early Proterozoic)**—Biotite schist, biotite-muscovite schist. Protoliths include black shale (now pyrite-rich), tuffaceous shale, and siltstone. Locally contains massive chert beds. Includes part of the Loues Formation (Redden, 1968), part of the Oreville Formation, and units east of the Grand Junction fault in the Berne quadrangle (Redden, 1968)

Xcg — **Metasedimentary rocks (Early Proterozoic)**—Conglomeratic biotite phyllite, siliceous biotite phyllite, mica schist, quartzite, and iron-formation. Protoliths include debris-flow conglomerate, quartzite, graywacke, ferruginous shale, and iron-formation

Xgb — **Metagabbro (Early Proterozoic)**—Amphibolite, greenstone, actinolite schist, and serpentinite. Protoliths include gabbro, norite, and quartz-rich gabbro sills of at least two different ages. Sills that intrude the Boxelder Creek Formation (Redden, 1981) are about 2.2 Ga; sills that intrude the Hay Creek Greenstone (Bayley, 1972b), and Roberts Draw Formation and Buck Mountain Formation (Redden, 1981) are about 2.0 Ga (Z. E. Peterman, unpub. data, 1985)

Xb — **Metabasalt (Early Proterozoic)**—Amphibolite, greenstone, and actinolite schist. Protoliths include basalt and minor bodies of gabbro. Interflow units include tuffaceous shale, black shale, massive chert, carbonate- and silicate-facies iron-formation, and mafic tuff. Included are the Hay Creek Greenstone, Rapid Creek Greenstone (Bayley, 1972c), Crow Formation (Redden, 1963), members of the Vanderlehr Formation (Redden, 1968), parts of the Flag Rock Formation (Dodge, 1942), and metabasaltic units in the Keystone and Tinton areas. Those in the latter area may be Archean in age

Xsi — **Metasedimentary rocks (Early Proterozoic)**—Phyllite, slate, and biotite schist containing minor chert and amphibolite. Protoliths include tuffaceous shale, siltstone, and black shale interbedded with minor amounts of volcaniclastic rocks, carbonate- and silicate-facies iron-formation, and basalt. Locally intruded by thin sills of metagabbro. Includes the Poverty Gulch Slate, Nahant Schist, and Irish Gulch Slate (Bayley, 1972c), and Northwestern Formation (Hosted and Wright, 1923)

Xq — **Metaquartzite (Early Proterozoic)**—Quartzite, siliceous schist, and minor chert. Protoliths include quartzite with interbedded siltstone and shale. Includes the Ellison Formation (Hosted and Wright, 1923), Buck Mountain Formation, Moonshine Gulch Quartzite (Bayley, 1972c), and a large area of quartzite and siltstone south of Harney Peak. In the northeastern belt, the unit fines upward (west) and includes the Gingras Draw Slate (Bayley, 1972b)

Xsc — **Metasedimentary rocks (Early Proterozoic)**—Siliceous biotite phyllite, calcareous biotite phyllite, and schist. Protoliths include black shale and chert, calcareous and carbonaceous shale, and a minor amount of siltstone. Includes the Poorman Formation (Hosted and Wright, 1923) and the Reausaw Slate (Bayley, 1972b), which intertongues with metabasalt

Xd — **Metasedimentary rocks (Early Proterozoic)**—Marble, phyllite, and calcareous phyllite. Protoliths are predominantly dolomite and shale and minor amounts of quartzite. Includes the Roberts Draw Formation

Xc — **Metaconglomerate (Early Proterozoic)**—Conglomeratic, siliceous schist, feldspathic schist, and minor marble. Protoliths include conglomerate and quartzite and minor amounts of arkose, limestone, and shale. In the Nemo area, map unit includes taconite conglomerate and is equivalent to parts of the Estes Conglomerate and Boxelder Creek Quartzite (Bayley, 1972b), and all of the Estes Formation (Redden, 1981). In the Bear Mountain area, map unit includes part of the Vanderlehr Formation. The probable equivalent unit forms large inclusions within the Harney Peak Granite

Xif — **Iron-formation (Early Proterozoic)**—Iron-formation, ferruginous chert, and minor mica schist. Protoliths include oxide-, carbonate-, silicate-, and sulfide-facies iron-formation and interbedded tuffaceous rocks. Included are the Homestake Formation (Hosted and Wright, 1923), Rochford Formation and Montana Mine Formation (Bayley, 1972c), Nemo Iron-formation and Benchmark Iron-formation (Redden, 1981), and iron-formation in the Keystone area and in minor occurrences throughout the Precambrian core of the Black Hills. Oxide-facies taconite iron-formation is restricted to the Nemo area, where the older of two different stratigraphic units may be Late Archean in age

Xcq — **Metaconglomerate and metaquartzite (Early Proterozoic)**—Conglomeratic and feldspathic schist, biotite schist, taconite, and phyllite. Protoliths include quartzite and minor amounts of shale, dolomite, taconite conglomerate, pyritiferous fluvial conglomerate, and fanglomerate. Includes parts of the Estes Conglomerate and all of the Boxelder Creek Formation (Redden, 1981)

Xp — **Pegmatite (Early Proterozoic or Late Archean?)**—Pegmatite bodies in the Tinton area that may be Late Archean or may be the age of the Harney Peak Granite

Wgr — **Granite (Late Archean)**—Granite and gneissic granite. Includes the Little Elk Granite (U-Th-Pb zircon age of 2.51±0.07 Ga; recalculated from data in Zartman and Stern, 1967) in the Nemo area, granitic rocks in the Bear Lodge Mountains (U-Th-Pb zircon minimum age of about 2.63 Ga; Staatz, 1983), and the granite of Bear Mountain (Rb-Sr whole-rock age of 2.40±0.09 Ga; data of Ratté and Zartman (1970) (recalculated from unpub. data, R. E. Zartman, 1985) at Bear Mountain

Wos — **Older metasedimentary rocks (Late Archean)**—Phyllite, mica schist, and biotite-plagioclase schist. Protoliths include siltstone and shale at Bear Mountain and coarse clastic metasedimentary rocks and possibly the taconite Nemo Iron-formation in the Nemo area. The coarse clastic rocks are intruded by the Little Elk Granite near Nemo (J. A. Redden, unpub. mapping, 1985), and the biotite-plagioclase schist at Bear Mountain (Ratté, 1980) is intruded by the granite of Bear Mountain

Contact—Dashed where approximately located

Fault—Dashed where approximately located; dotted where concealed. Bar and ball on downthrown side. Arrows show sense of displacement

Anticline—Dotted where concealed; arrow shows direction of plunge

Syncline—Dotted where concealed

Monocline—Axis located on steepest part of structure

Dome

REFERENCES CITED

Anna, Lawrence, 1973, Geology of the Kirk Hill area, Meade County, South Dakota: Rapid City, South Dakota School of Mines and Technology, M.S. thesis, 47 p.

Bassett, W. A., 1961, Potassium-argon age of Devil's Tower, Wyoming: Science, v. 134, no. 3487, p. 1373.

Bayley, R. W., 1970, Structure and mineralization of Precambrian rocks in the Galena-Roubaix district, Black Hills, South Dakota: U.S. Geological Survey Bulletin 1312-E, 15 p.

———1972a, Geologic field compilation map of the northern Black Hills, South Dakota: U.S. Geological Survey Open-File Report 72-29, scale 1:48,000.

———1972b, Preliminary geologic map of the Nemo district, Black Hills, South Dakota: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-712, scale 1:24,000.

———1972c, A preliminary report on the geology and gold deposits of the Rochford district, Black Hills, South Dakota: U.S. Geological Survey Bulletin 1332-A, 24 p.

Beck, J. A., 1976, Geology of the Lexington Hill-Pillar Peak area, Lawrence County, South Dakota: Rapid City, South Dakota School of Mines and Technology, M.S. thesis, 102 p.

Bell, Henry, III, and Post, E. V., 1971, Geology of the Flint Hill quadrangle, Fall River County, South Dakota: U.S. Geological Survey Bulletin 1063-M, p. 505-586.

Boyd, T. M., 1975, Bedrock geology of the Whitewood Peak area, Lawrence County, South Dakota: Toledo, Ohio, University of Toledo, M.S. thesis, 89 p.

Braddock, W. A., 1963, Geology of the Jewel Cave SW quadrangle, Custer County, South Dakota: U.S. Geological Survey Bulletin 1063-G, p. 217-268.

Brobst, D. A., 1961, Geology of the Dewey quadrangle, Wyoming-South Dakota: U.S. Geological Survey Bulletin 1063-B, p. 13-60.

Brobst, D. A, and Epstein, J. B., 1963, Geology of the Fanny Peak quadrangle, Wyoming-South Dakota: U.S. Geological Survey Bulletin 1063-I, p. 323-377.

Cattermole, J. M., 1969, Geologic map of the Rapid City West quadrangle, Pennington County, South Dakota: U.S. Geological Survey Geologic Quadrangle Map GQ-828, scale 1:24,000.

———1972, Geologic map of the Rapid City East quadrangle, Pennington County, South Dakota: U.S. Geological Survey Geologic Quadrangle Map GQ-986, scale 1:24,000.

Connor, J. J., 1963, Geology of the Angostura Reservoir quadrangle, Fall River County, South Dakota: U.S. Geological Survey Bulletin 1063-D, p. 85-126.

Cuppels, N. P., 1963, Geology of the Clifton quadrangle, Wyoming and South Dakota: U.S. Geological Survey Bulletin 1063-H, p. 271-321.

Darton, N. H., 1902, Oelrichs [quadrangle], South Dakota: U.S. Geological Survey Geologic Atlas of the United States, Folio 85, 6 p.

———1904, Newcastle [quadrangle], Wyoming-South Dakota: U.S. Geological Survey Geologic Atlas of the United States, Folio 107, 9 p.

———1905, Sundance [quadrangle], Wyoming-South Dakota: U.S. Geological Survey Geologic Atlas of the United States, Folio 127, 12 p.

Darton, N. H. and O'Harra, C. C., 1905, Aladdin [quadrangle], Wyoming-South Dakota-Montana: U.S. Geological Survey Geologic Atlas of the United States, Folio 128, 8 p.

———1909, Belle Fourche [quadrangle], South Dakota: U.S. Geological Survey Geologic Atlas of the United States, Folio 164, 9 p.

Darton, N. H., and Paige, Sidney, 1925, Central Black Hills [quadrangle], South Dakota: U.S. Geological Survey Geologic Atlas of the United States, Folio 219, 34 p.

Darton, N. H., and Smith, W. S. T., 1904, Edgemont [quadrangle], South Dakota: U.S. Geological Survey Geologic Atlas of the United States, Folio 108, 10 p.

Denson, N. M., and Horn, G. H., 1975, Geologic and structure map of the southern part of the Powder River Basin, Converse, Niobrara, and Natrona Counties, Wyoming: U.S. Geological Survey Miscellaneous Investigations Series Map I-877, scale 1:125,000.

DeWitt, Ed, 1973, The geology of the Bear Butte area, Fort Meade quadrangle, South Dakota: Rapid City, South Dakota School of Mines and Technology, Senior thesis, 45 p.

Dobbin, C. E., Kramer, W. B., and Horn, G. H., 1957, Geologic and structure map of the southeastern part of the Powder River Basin, Wyoming: U.S. Geological Survey Oil and Gas Investigations Map OM-185, scale 1:125,000.

Dodge, T. A., 1942, Amphibolites of the Lead area, northern Black Hills, South Dakota: Geological Society of America Bulletin, v. 53, p. 561-584.

Elwood, M. W., 1979, General geology of the Black Buttes, northwestern Black Hills, Crook County, Wyoming: Earth Science Bulletin, v. 12, no. 1, p. 1-16.

Fashbaugh, E. F., 1979, Geology of igneous extrusive and intrusive rocks in the Sundance area, Crook County, Wyoming: Grand Forks, University of North Dakota, M.S. thesis, 97 p.

Fisher, J. K., 1969, Geology of the Citadel Rock area, Lawrence County, South Dakota: Rapid City, South Dakota School of Mines and Technology, M.S. thesis, 58 p.

Gasser, M. M., 1981, The geology of the southeast portion of the Deadman Mountain quadrangle, Black Hills, South Dakota: Rapid City, South Dakota School of Mines and Technology, M.S. thesis, 89 p.

Gott, G. B., and Schnabel, R. W., 1963, Geology of the Edgemont NE quadrangle, Fall River and Custer Counties, South Dakota: U.S. Geological Survey Bulletin 1063-E, p. 127-190.

Gott, G. B., Wolcott, D. E., and Bowles, C. G., 1974, Stratigraphy of the Inyan Kara Group and localization of uranium deposits, southern Black Hills, South Dakota and Wyoming: U.S. Geological Survey Professional Paper 763, 57 p.

Hadji-Sabbagh, Mehdi, 1979, Structural geology of the Crook Mountain and Whitewood area, Lawrence-Meade Counties, South Dakota: Rapid City, South Dakota School of Mines and Technology, M.S. thesis, 58 p.

Heidt, J. H., 1977, Geology of the Mount Theodore Roosevelt-Maitland area, Lawrence County, South Dakota: Rapid City, South Dakota School of Mines and Technology, M.S. thesis, 141 p.

Hill, D. J., Izett, G. A., and Naeser, C. W., 1975, Early Tertiary fission track ages of sphene from Devil's Tower and Missouri Buttes, Black Hills, northeastern Wyoming [abs.]: Geological Society of America Abstracts with Programs, v. 7, no. 5, p. 613-614.

Hosted, J. O., and Wright, L. B., 1923, Geology of the Homestake ore bodies and the Lead area of South Dakota: Engineering and Mining Journal, v. 115, p. 793-799, 836-843.

Jenner, G. A., Jr., 1984, Tertiary alkalic igneous activity, potassic fenitization, carbonatitic magmatism, and hydrothermal activity in the central and southeastern Bear Lodge Mountains, Crook County, Wyoming: Grand Forks, University of North Dakota, M.S. thesis, 232 p.

Jumnongthai, Manit, 1979, Geology of the Sugarloaf Mountain area, Lead, South Dakota: Rapid City, South Dakota School of Mines and Technology, M.S. thesis, 101 p.

Kirchner, J. G., 1971, The petrography and petrology of the phonolite porphyry intrusions of the northern Black Hills, South Dakota: Des Moines, University of Iowa, Ph.D. dissertation, 197 p.

Kleinkopf, M. D., and Redden, J. A., 1975, Bouger gravity, aeromagnetic, and generalized geologic maps of part of the Black Hills of South Dakota and Wyoming: U.S. Geological Survey Geophysical Investigations Map GP-903, scale 1:250,000.

Knechtel, M. M., and Patterson, S. H., 1962, Bentonite deposits of the northern Black Hills district, Wyoming, Montana, and South Dakota: U.S. Geological Survey Bulletin 1082-M, p. 893-1030.

Krabulec, K. A., 1981, Precambrian geology of the Roubaix district, Black Hills, South Dakota: Rapid City, South Dakota School of Mines and Technology, M.S. thesis, 46 p.

Kuhl, T. O., 1982, Precambrian geology of the Deerfield area, Pennington County, South Dakota: Rapid City, South Dakota School of Mines and Technology, M.S. thesis, 69 p.

Larsen, R. K., 1977, Geology, alteration and mineralization of the northern Cutting Stock, Lawrence County, South Dakota: Rapid City, South Dakota School of Mines and Technology, M.S. thesis, 147 p.

Lisenbee, A. L., 1985, Tectonic map of the Black Hills uplift, Montana, Wyoming, and South Dakota: Geological Survey of Wyoming Map Series 13, scale 1:250,000.

Love, J. D., and Christiansen, A. C., 1985, Geologic Map of Wyoming: U.S. Geological Survey Map, 3 sheets, scale 1:500,000.

Love, J. D., Christiansen, A. C., and McGrew, L. W., compilers, 1977, Geologic map of the Newcastle 1° by 2° quadrangle, northeastern Wyoming and western South Dakota: U.S. Geological Survey Miscellaneous Field Studies Map MF-883, scale 1:250,000.

———1978, Preliminary geologic map of the Gillette 1° by 2° quadrangle, northeastern Wyoming and western South Dakota: U.S. Geological Survey Open-File Report 78-343, scale 1:250,000.

Mapel, W. J., and Pillmore, C. L., 1963a, Geology of the Inyan Kara Mountain quadrangle, Crook and Weston Counties, Wyoming: U.S. Geological Survey Bulletin 1121-M, 56 p.

———1963b, Geology of the Newcastle area, Weston County, Wyoming: U.S. Geological Survey Bulletin 1141-N, 83 p.

———1964, Geology of the Upton quadrangle, Crook and Weston Counties, Wyoming: U.S. Geological Survey Bulletin 1181-J, 54 p.

Matthews, C. V., 1979, Geology of the central Vanocker laccolith area, Meade County, South Dakota: Rapid City, South Dakota School of Mines and Technology, M.S. thesis, 110 p.

McDowell, F. W., 1971, K-Ar dates of igneous rocks from the western United States: Isochron/West, v. 2, p. 1-16.

McGregor, E. E., and Cattermole, J. M., 1973, Geologic map of the Rapid City NW quadrangle, Meade and Pennington Counties, South Dakota: U.S. Geological Survey Geologic Quadrangle Map GQ-1093, scale 1:24,000.

Mukherjee, N. S., 1968, Geology and mineral deposits of the Galena-Gilt Edge area, northern Black Hills, South Dakota: Golden, Colorado School of Mines, Ph.D. dissertation, 288 p.

Noble, J. A., and Harder, J. O., 1948, Stratigraphy and metamorphism in a part of the northern Black Hills and the Homestake mine, Lead, South Dakota: Geological Society of America Bulletin, v. 59, p. 941-975.

Norby, J. W., 1984, Geology and geochemistry of Precambrian amphibolites and associated gold mineralization, Tinton district, Lawrence County, South Dakota and Crook County, Wyoming: Rapid City, South Dakota School of Mines and Technology, M.S. thesis, 144 p.

Norton, J. J., 1976, Field compilation map of the geology of the Keystone area, Black Hills, South Dakota: U.S. Geological Survey Open-File Report 76-297, scale 1:20,000.

O'Toole, F. S., 1981, Petrology of the Cenozoic phonolites and related rocks of the Houston Creek area, Bear Lodge Mountains, Wyoming: Grand Forks, University of North Dakota, M.S. thesis, 112 p.

Pillmore, C. L., and Mapel, W. J., 1963, Geology of the Nefsy Divide quadrangle, Crook County, Wyoming: U.S. Geological Survey Bulletin 1121-E, 52 p.

Post, E. V., 1967, Geology of the Cascade Springs quadrangle, Fall River County, South Dakota: U.S. Geological Survey Bulletin 1063-L, p. 443-504.

Ratté, J. C., 1980, Geologic map of the Medicine Mountain quadrangle, Pennington County, South Dakota: U.S. Geological Survey Open-File Report 80-1083, scale 1:24,000.

Ratté, J. C., and Wayland, R. G., 1969, Geology of the Hill City quadrangle, Pennington County, South Dakota—A preliminary report: U.S. Geological Survey Bulletin 1271-B, 14 p.

Ratté, J. C., and Zartman, R. E., 1970, Bear Mountain gneiss dome, Black Hills, South Dakota—age and structure [abs.]: Geological Society of America Abstracts with Programs, v. 2, no. 5, p. 345.

Redden, J. A., 1963, Geology and pegmatites of the Fourmile quadrangle, Black Hills, South Dakota: U.S. Geological Survey Professional Paper 297-D, p. 199-291.

———1968, Geology of the Berne quadrangle, Black Hills, South Dakota: U.S. Geological Survey Professional Paper 297-F, p. 343-408.

———1980, Geology and uranium resources in Precambrian conglomerates of the Nemo area, Black Hills, South Dakota: U.S. Department of Energy Open-File Report GJBX-127(80), 147 p. [available from U.S. Geological Survey Open-File Services Section, P.O. Box 25046, Denver, CO 80225].

———1981, Summary of geology of the Nemo area, *in* Rich, F. J., ed., Geology of the Black Hills, South Dakota and Wyoming: Geological Society of America Guidebook, Rocky Mountain Section, Annual Meeting, Rapid City, S. Dak., 1981, Falls Church, Va., American Geological Institute, p. 193-210.

Redden, J. A., Norton, J. J., and McLaughlin, R. J., 1982, Geology of the Harney Peak Granite, Black Hills, South Dakota: U.S. Geological Survey Open-File Report 82-481, 18 p.

Redden, J. A., Obradovich, J. D., Naeser, C. W., Zartman, R. E., and Norton, J. J., 1983, Early Tertiary age of pitchstone in the northern Black Hills, South Dakota: Science, v. 220, p. 1153-1154.

Riley, G. H., 1970, Isotopic discrepancies in zoned pegmatites, Black Hills, South Dakota: Geochimica et Cosmochimica Acta, v. 34, p. 713-725.

Robinson, C. S., Mapel, W. J., and Bergendahl, M. H., 1964, Stratigraphy and structure of the northern and western flanks of the Black Hills uplift, Wyoming, Montana, and South Dakota: U.S. Geological Survey Professional Paper 404, 134 p.

Rockey, D. L., 1974, Geology of the eastern Vanocker laccolith area, Meade County, South Dakota: Rapid City, South Dakota School of Mines and Technology, M.S. thesis, 44 p.

Ryan, J. D., 1964, Geology of the Edgemont quadrangle, Fall River County, South Dakota: U.S. Geological Survey Bulletin 1063-J, p. 379-426.

Schnabel, R. W., 1963, Geology of the Burdock quadrangle, Fall River and Custer Counties, South Dakota: U.S. Geological Survey Bulletin 1063-F, p. 191-215.

Shapiro, L. H., and Gries, J. P., 1970, Ore deposits in rocks of Paleozoic and Tertiary age, northern Black Hills, South Dakota: U.S. Geological Survey Open-File Report 70-300, 235 p.

Smith, W. C., and Page, L. R., 1941, Tin-bearing pegmatites of the Tinton district, Lawrence County, South Dakota—a preliminary report: U.S. Geological Survey Bulletin 922-T, p. 594-630.

Sofranoff, S. E., 1979, Geology, alteration and mineralization of the Carbonate mining district and surrounding area, Lawrence County, South Dakota: Rapid City, South Dakota School of Mines and Technology, M.S. thesis, 150 p.

Staatz, M. H., 1983, Geology and description of thorium and rare-earth deposits in the southern Bear Lodge Mountains, northeastern Wyoming: U.S. Geological Survey Professional Paper 1049-D, 52 p.

Steiger, R. H., and Jaeger, E., 1977, Subcommission on geochronology—convention and use of decay constants in geo- and cosmochronology: Earth and Planetary Science Letters, v. 36, p. 359-362.

Usiriprisan, Chamroon, 1979, Geology of the Woodville Hills intrusive body, Lawrence County, South Dakota: Rapid City, South Dakota School of Mines and Technology, M.S. thesis, 74 p.

Van Lieu, J. A., 1969, Geologic map of the Four Corners quadrangle, Wyoming and South Dakota: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-581, scale 1:48,000.

Welch, C. M., 1974, A preliminary report on the geology of the Mineral Hill area, Crook County, Wyoming: Rapid City, South Dakota School of Mines and Technology, M.S. thesis, 83 p.

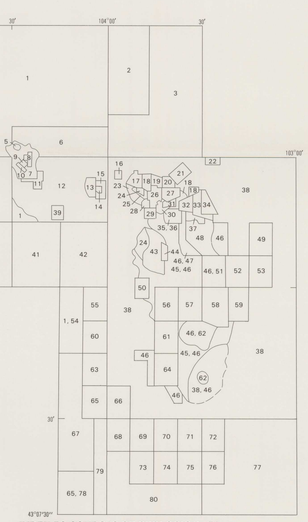
White, S. F., 1980, Petrology of the Cenozoic igneous rocks of the Lytle Creek area, Bear Lodge Mountains, Wyoming: Grand Forks, University of North Dakota, M.S. thesis, 69 p.

Wilkinson, Michael, 1982, Petrology and alteration in the core of the Bear Lodge Tertiary intrusive complex, Bear Lodge Mountains, Crook County, Wyoming: Grand Forks, University of North Dakota, M.S. thesis, 127 p.

Wolcott, D. E., 1967, Geology of the Hot Springs quadrangle, Fall River and Custer Counties, South Dakota: U.S. Geological Survey Bulletin 1063-K, p. 427-442.

Wolcott, D. E., Bowles, C. G., Brobst, D. A., and Post, E. V., 1962, Geologic and structure map of the Minnekahta NE quadrangle, Fall River and Custer Counties, South Dakota: U.S. Geological Survey Mineral Investigations Field Studies Map MF-242, scale 1:24,000.

Zartman, R. E., and Stern, T. W., 1967, Isotopic age and geologic relationships of the Little Elk Granite, northern Black Hills, South Dakota: *in* Geological Survey research 1967, U.S. Geological Survey Professional Paper 575-D, p. D157-D163.



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PRIMARY SOURCES

1. Robinson, Mapel, and Bergendahl (1964)
2. Knechtel and Patterson (1962)
3. Darton and O'Hara (1909)
4. Pillmore and Mapel (1963)
5. White (1980)
6. Darton and O'Hara (1905)
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10. O'Toole (1981)
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23. Shapiro and Gries (1970)
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26. Noble and Harder (1948)
27. Beck (1976)
17–28. Kirchner (1971)
28. Jumnongthai (1979)
29. Usiriprisan (1979)
30. G.M. French, unpub. mapping, 1984
31. Mukherjee (1968)
32. Anna (1973)
33. Matthews (1979)
34. Rockey (1974)
35. Krabulec (1981)
36. Bayley (1970)
37. Gasser (1981)
38. Darton and Paige (1925)
39. Elwood (1979)
40. Mapel and Pillmore (1964)
41. Mapel and Pillmore (1963a)
42. Van Lieu (1969)
43. Bayley (1972c)
44. Richard Cleath, unpub. mapping, 1984
45. Kleinkopf and Redden (1975)
46. J.A. Redden, unpub. mapping, 1984
47. Bayley (1972b)
48. Redden (1980)
49. McGregor and Cattermole (1973)
50. Kuhl (1982)
51. J.J. Norton, unpub. mapping, 1984
52. Cattermole (1969)
53. Cattermole (1972)
54. Mapel and Pillmore (1963b)
55. Darton (1904)
56. Ratté (1980)
57. Ratté and Wayland (1969)
58. Norton (1976)
59. P.H. Rahn, unpub. mapping, 1984
60. Brobst and Epstein (1963)
61. Redden (1968)
62. Redden, Norton, and McLaughlin (1982)
63. Cuppels (1963)
64. Redden (1963)
65. Brobst (1961)
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67. Dobbin, Kramer, and