U.S. DEPARTMENT OF THE INTERIOR
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TO ACCOMPANY MAP I–2291–C

MAPS SHOWING DISTRIBUTION, COMPOSITION, AND AGE OF EARLY AND MIDDLE CENOZOIC VOLCANIC CENTERS IN IDAHO, MONTANA, WEST-CENTRAL SOUTH DAKOTA, AND WYOMING

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DISCUSSION

This map is the third of a series showing the distribution, composition, and age of early and middle Cenozoic volcanic centers in the western conterminous United States. The maps are designed primarily as a data base of igneous systems, a major geologic environment known to promote and host mineral deposits. The data shown provide the basic information necessary for derivative studies such as the development of geologic concepts to identify and assess igneous-related mineral deposits and(or) mineralized systems. In addition, this map series shows the temporal and spatial relationships of early and middle Cenozoic igneous rocks and their geochemical and age associations, at a single common scale, within the many different igneous centers in the western states. This map series can also be used as a base for studies of volcanology, volcanotectonics, and the general geology of volcanic and related rocks. Original sources were consulted wherever possible in construction of these maps, but in areas of meager data I interpreted the general composition and age of the igneous rocks. This procedure was necessary in order to resolve internal problems and to maintain a standard treatment for meaningful comparison of data throughout the map series.

In this map series the early and middle Cenozoic time frame extends from about 58 Ma to 16 Ma; 16 Ma is the maximum age cutoff for a published map series designed as a guide for the evaluation of igneous-related geothermal resources (for the comparable Idaho, Montana, Wyoming, and western South Dakota region, see Luedke and Smith, 1983). Within this early and middle Cenozoic time frame, the ages of the volcanic rocks are arbitrarily divided into three time increments: 58–37 Ma, 37–24 Ma, and 24–16 Ma. The ages of 58, 37, and 24 Ma, respectively, represent the approximate Paleocene-Eocene, Eocene-Oligocene, and Oligocene-Miocene boundaries (Berggren and others, 1985).

Igneous rocks of the early and middle Cenozoic time frame are principally related to volcanotectonic activity occurring within this time span. This map, however, comprising the northern Rockies is dominated by rock masses of early Cenozoic age, and by units of sub-volcanic or intrusive rather than volcanic origin, particularly in Idaho. In comparison, the maps encompassing the middle and southern Rockies (Luedke, 1993 and in press) show a larger percentage of volcanic rocks progressively southward and are more inclusive and representative of early and middle Cenozoic times. Most volcanic rock units shown on the maps generally fit well within the selected time intervals. Locally, a few rock units that are at or within about a million years of a time boundary (particularly the 24-Ma boundary) were included with the dominant younger or older unit of the region in order to maintain geologic, petrologic, and tectonic continuity. Areas in eastern Arizona and western New Mexico (Luedke, 1993) and southwestern Utah (Luedke, in press) necessitated such unit assignments. Perhaps of significance is the fact that no rocks with ages in the youngest time interval (Miocene) occur in the region encompassed by this map except for a minette dike (22 Ma) in the Wind River basin about 40 km northwest of Lander, Wyo. Local extrusive masses of dominantly mafic composition and radiometric ages of 16–17 Ma crop out in western Idaho, but these rocks are related to and a part of the extensive volcanic fields in neighboring Oregon and Washington and were included on the late Cenozoic maps (Luedke and Smith, 1982, 1983, and 1984). A specific rock unit or volcanic field may have some ages that appear inconsistent with the majority of ages shown, e.g., the Absaroka Range in northwestern Wyoming where the dominant time interval (Eocene) was assigned. The few younger ages shown are for intrusives within the Absaroka field and probably reflect slightly younger intrusive activity or localized mineralization and alteration. All known ages for a specific unit within the 58–16 Ma time frame are shown.

Some Laramide magmatic and tectonic events that started in the Late Cretaceous or Paleocene continued into middle Eocene time (Mutschler and others, 1987), or served as precursors to similar events later in the Cenozoic. In regions mostly south of the area included in this map, volcanism and associated intrusions commenced in the very latest Eocene following a quiescence of volcanic activity in late Eocene time. This igneous activity continued on a major scale through the Oligocene, into the Miocene, to the onset of late Cenozoic volcanism and associated extensional tectonism characteristic of the Basin and Range province but also reflected in bordering regions (Christiansen and Lipman, 1972; Lipman and others, 1972; Christiansen, 1989). Because of the extraordinary amount of new geological, geochemical, geophysical, and geochronological data released during the last two decades, reanalysis of Laramide and post-Laramide volcanotectonic events is justified. Keith and Wilt (1986) have done such a synthesis of Laramide events principally in Arizona and environs, and Mutschler and others (1987) similarly studied the effects of late Mesozoic and Cenozoic magmatism in Colorado and environs.

In order to show some continuity to earlier magmatic activity, a few areas of igneous rocks are outlined that are related to known Laramide magmatic or tectonic belts within the Rocky Mountain Cordillera, for instance those having ages spanning the 58 Ma limit for this map series. These mostly pre-58 Ma plutonic complexes of stocks, laccoliths, sills, and dikes, and the volcanic Adel Mountains, are located predominantly in the alkalic (high-potassium) igneous province of central Montana east of the Rocky Mountain front.

The volcanic rocks, and associated contemporaneous plutonic rocks, have been classified using a non-genetic system into five major types based primarily upon their known or inferred silica-content:

1. Feldspathoidal basalts including basanite, tephrite, and other rare alkalic rocks	Less than 46 percent SiO_2
2. Basalt, including trachybasalt and hawaiite	46 – 54 percent SiO_2
3. Andesite, including trachyandesite and phonolite	54 – 62 percent SiO_2
4. Dacite, including rhyodacite, quartz latite, and trachyte	62 – 70 percent SiO_2
5. Rhyolite	More than 70 percent SiO_2

This simplistic rock classification, not desirable for detailed volcanological purposes, emphasizes the dominant rock type within a given region, although in any specific area several rock types may be intermixed. This rock classification is the same as that used on the map of late Cenozoic volcanic rocks (Luedke and Smith, 1983), thereby permitting easy comparison.

Isotopically determined age data are referenced to the first or original source where possible. Potassium-argon ages have been recalculated where necessary using the conversion tables of Dalrymple (1979) prepared for the decay constants and isotopic abundances adopted by the IUGS Subcommission on Geochronology (Steiger and Jager, 1977). Multiple ages at a given locality are shown when cartographically possible. Some areas, for example, in the Challis, Great Falls, and Lewistown 1° by 2° quadrangles (fig. 1) have had more age determinations made than can be shown, and an arbitrary selection was made.

Cited references for geologic, age, and chemical information are indicated in figure 2. Several important general references are cited separately at the end and are not numbered chronologically.

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