DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY

ATLAS OF METAL AND NONMETAL MINERAL PROVINCES CONTERMINOUS U. S.
OPEN-FILE REPORT 79-576F
TOOKER-MERCURY

Planimetric Base from National Atlas 1: 7 500 000, 1970

SCALE 1:5 000 000
100 0 100 200 300 400 500 MILES
100 0 100 200 300 400 500 600 700 KILOMETRES

PRELIMINARY MAP OF MERCURY PROVINCES IN THE CONTERMINOUS UNITED STATES

BY

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INTRODUCTION

The resource areas shown on the mercury province map are the best sites for the discovery of additional domestic supplies of this metal, which has become an essential commodity in advanced industrial nations. The U.S. Bureau of Mines (1976) reported that the United States imported 73 percent of its needs in 1975 from Canada, Algeria, Mexico, and Spain; these imports approximated about one-third of world production at that time. Partly spurred on by environmental regulations, the amount of mercury recycled in 1975 amounted to about 60 percent of the then-current domestic production (Ryan, 1976); however, some uses are dissipative, precluding recycling. Many uses of mercury have no practical or desirable substitution potential. Domestic sources undoubtedly will continue to be insufficient to meet the needs projected by Cammarota (1976), but the problems of mercury poisoning and pollution, which have lead to legal restrictions, ultimately may have some impact on the pattern of future domestic production and use of this material. Future requirements by industry for mercury, and its uncertain availability from abroad are believed sufficient to justify consideration of the future possibilities for domestic production of mercury. The primary concern of the mercury province map is to identify these possibilities.

The map shows the generally restricted areas in the conterminous United States where known mercury deposits are located. Preliminary estimates of the resource potential for the provinces are made, and a positive assessment of the adequacy of existing geologic knowledge about mercury resources indicates a measure of confidence in the province estimate.

The location of cinnabar deposits shown are from the computer-based (CRIB) map by Peterson and others (1977), and earlier reports by Bailey (1962, 1964a, 1964b, 1966, 1969), Brooks and Bailey (1969), and Bailey and others (1973). Noncinnabar localities were compiled from Jolly and Heyl (1968), Lovering and others (1966), McNeal and Rose (1974), Donnell and Shaw (1977), and Joensure (1971). The critical advice of E. H. Bailey and J. J. Rytuba in preparing this brief summary is appreciated. Selected geologic information used on the map is from the geologic map of the United States (King and Beikman, 1974), and the rationale for province maps and some of the terms used in this map and the atlas of metal and nonmetal provinces, of which this map is a part, are discussed and defined in a companion background report by Tooker (1979).

DISTINGUISHING PROVINCE MAP FEATURES

The mercury province map shows the distribution, magnitude, and geologic types of known deposits and occurrences in restricted geographic and geologic terranes. The localities (shown as dot symbol) represent concentrations of mercury at some value greater than the Clarke (average percentage of an element in the crust) where cinnabar, the main ore mineral of mercury, accumulated in a geochemical environment favorable for formation of HgS. Similar lesser concentrations of noncinnabar mercury (shown as a plus symbol) may occur in a variety of sedimentary, and metamorphic rocks, soils, fossil fuels, and in hydrothermal jasperoid and ore deposit mineral environments. A province (short dashed boundary) represents a region containing a small number or cluster of primary or byproduct cinnabar deposits, or unevaluated occurrences that were found in comparable geologic environments. No distinction as to economic or subeconomic character is implied in this definition of a province. Where possible, the boundaries are drawn on the basis of geologic formational units, resulting in some cases, in a number of detached, outlying areas. In the absence of a prominent mappable geologic feature, the province boundary has been drawn arbitrarily. Less well known territories containing only widely dispersed mercury localities may be considered an occurrence area, the nature of the dispersion may be a natural pattern or the result of insufficient data about mercury. Another set of solitary localities that do not seem to fall into a regional geologic pattern at present is also shown.

Deposits and occurrences of the cinnabar-type materials shown on this map are classified (Tooker, 1979), into large and small sizes; and large deposits are further subdivided into those which were active or inactive in 1975, the base year used in the atlas. Large deposits are those whose combined production and remaining minable minerals are in excess of 75,000 flasks (about 2,587 tonnes) of mercury. For sake of comparison, this amount of mercury would have had a value of about $10 million in 1976 dollars and prices, and it represented about 1.8 times the United States' primary mercury requirements (in 1975). Large type A deposits known to have been active producers in 1975, according to U.S. Geological Survey information and confirmed in an international survey of mining (Mining Mag., 1976), provide an indication of the magnitude of recent domestic mercury mining. Type B (large-size inactive) deposits were former producers now considered mined out or temporarily closed, which may or may not contain minable or subeconomic extensions (hypothetical resources). Type B deposits provide a comparison of past mercury mining activity with that at present. A remaining large group of small type C deposits and occurrences (<75,000 flasks of mercury) may represent past, present, or possible producers of primary or byproduct mercury, or represent an unevaluated reported presence of that metal.

The types and geologic setting for mercury concentrations (as cinnabar) are simple and somewhat restricted (Bailey, 1959; Bailey and others, 1973; and Bailey and Smith, 1964). At the risk of oversimplification, some of the main geologic features of the concentrations of cinnabar described are summarized here. The metal occurs primarily in young orogenic belts, such as in the western United States, in which crustal rocks have undergone volcanic and tectonic activity. Ore-forming minerals, mainly cinnabar (HgS), were transported and deposited from relatively low temperature (50°-200°) hydrothermal solutions; the metal can also move in a vapor phase.

Deposits most commonly are small, irregular, and erratically distributed. Deposition occurred near the surface in a variety of preexisting favorable host rocks and structures, and major world mine depths seldom exceed 610 m. Thus, although probably formed throughout geologic history, old mercury deposits have been either destroyed by erosion or were covered over. Mercury may also be obtained as a coproduct from the mining of other metals, such as zinc sulfides in New York, and disseminated gold at Carlin, Nev. Subeconomic amounts of mercury occur in a number of other geologic environments: in hot springs and geothermal areas; with hydrothermal base-metal ores in sedimentary rocks and structures associated with intrusive rocks; and in some coal and petroleum deposits.

The main productive deposits as well as most clusters of mercury occurrences lie in the western part of the Cordilleran belt, which has been divided into two geologic regions (Tooker, 1979). The eastern section, which contains Archean and Proterozoic (Precambrian) basement rocks (based on Stewart, 1978; King and Beikman, 1974) as well as Phanerozoic cover rocks, is called old continent crust, and the western part, composed of oceanic- and island-arc derived rocks that were added (accreted) to the old continent during Phanerozoic time, is called oceanic crust. The number of mercury deposits and occurrences declines markedly east of an inferred boundary zone that separates these two crustal plates. Oceanic crust rocks, as typified by Mesozoic eugeosynclinal sediments and volcanic rocks intruded by serpentine and ophiolitic assemblage rocks in the California Coast Ranges, contain mercury mainly in fracture filling, veins, and replacements in silica-carbonate rock, an alteration of serpentine. Mercury may also occur in and around hot springs.

The eastern counterpart of the border zone between old continent-oceanic crusts is not marked by a comparable distribution of mercury deposits and occurrences. This may be due to insufficient information, but the proportionally larger amount of older Phanerozoic rocks, greater degree of metamorphism, and the higher degree of uplift and erosion in the Appalachian belt may have stripped away such potential cinnabar mercury concentrations.

The noncinnabar concentrations of mercury located on the map are very subeconomic indicators of the occurrence of the metal, and no provinces have been delineated because the extent of their location and geologic environments are incompletely known. Weathering of surface rocks has been estimated to release as much as 230 metric tons of mercury per year, and 3,000 tonnes (80,000 flasks) per year are emitted by the burning of fossil fuels (Joensure, 1971). Some of this mercury is available for redeposition elsewhere and undoubtedly contributed to the large trace concentrations found in some sedimentary rocks. The content of mercury in sulfide ores in minerals other than cinnabar probably is higher than in coal, but the relative tonnages of sulfides mined is much smaller. Subeconomic as these diverse sources seen at present, they ought not be overlooked in considering potential byproduct mercury resources.

MERCURY PROVINCES

Of the 11 provinces identified with variable degrees of certainty, only the first three listed in table 1 contain significant economic deposits at present. The restricted distribution of the large type A and B deposits in the western Cordilleran belt suggests that the geologic regions most favorable for production are limited even though the metal seems to be widely distributed in oceanic plate rocks. Bailey (1966) points out that abundant clusters of type C deposits and occurrences shown on the map may in part represent small byproduct amounts of mercury in ores mined primarily for other metals. Byproduct possibilities should not be overlooked from the view of conservation as well as a new source of mercury. Not all provinces are well defined, either because of insufficient search or the sparseness of mercury occurrence. The preliminary estimates of resource potential in many provinces are also constrained by incomplete geologic resource data.

Province 1 includes a large irregular-shaped area generally east of the Sierra Nevada batholith, from southeast Oregon, western Nevada, to southeastern California, mostly in the western part of the Great Basin. The important productive mercury deposits in Nevada, at McDermitt (type A) and Cordero (type B), lie in the northern part of this province. Mercury localization in sedimentary and igneous rocks in Nevada is considered typical of deposits along the border zone between crustal plates, possibly overlying a deep subduction zone. Bailey (1964a) describes vein and disseminated deposits in altered andesite and rhyolite flows and breccias near steep faults, in flat-lying beds of locally hydrothermally silicified rhyolite tuff called opalite, and as replacements and fracture fillings in limestone. Mercury also occurs in and about hot springs and in geothermal wells along the western margin of the province. The province undoubtedly contains additional resource possibilities as remaining undiscovered primary deposits, marginal mercury occurrences that can be mined during periods of high prices, and byproduct mercury deposits and occurrences (Bailey, 1964a).

Province 2, the Coast Range of California, contains the classic New Almaden and New Idria mercury mining districts. Both are now type B deposits. The large deposits in the main range are surrounded by a number of type C deposits and occurrence. The flanking ranges on the west also contain lesser concentrations of type C localities. The productive deposits in this region seem to lie close to and generally just below a major thrust fault, believed to be a late Mesozoic subduction zone (Bailey, 1974) along which the oceanic plate plunged down beneath the existing continental plate. The few deposits in the Sierra foothills region east of the main Coast Range are included in this province because mercury occurs in comparable oceanic-type faulted rocks of Mesozoic age. Davis and Bailey (1966) expect that the Coast Range province will continue to be a major potential source area for mercury.

Provinces 4, 5, 6, and 9a, 9b, and 9c in Oregon, Idaho, and Washington occur in oceanic and border zone old continent (in northern Washington) plate rocks in a variety of geologic terranes, but to date no large deposits have been discovered. In Oregon, for example, mercury occurs in fracture, vein, and breccia fillings associated with faults, in volcanogenic sediments and volcanic formations, in structural traps in sedimentary and metamorphic rocks, and at the margins of intrusive plugs and dikes (Brooks and Bailey, 1969). At present the resource potential is believed low for individual deposits but may aggregate substantial amounts as a whole.

East of the boundary between the oceanic and old continent plates in the central part of the Cordilleran belt the sparse type C occurrences may be considered mainly to have potential as byproduct mercury provinces. Province 7, lying in the decollement zone of the Great Basin west of the Rocky Mountains and Colorado Plateau, contains a number of type C occurrences in faulted carbonate rock sequences associated with intrusive igneous rocks. Here mercury may be a potential byproduct of iron and base-metal mining. The deposits in Utah (Hilpert, 1964), Texas and Arkansas (Bailey, 1962) are considered more typical of sparse hydrothermal mercury accumulations preserved in rocks overlying old continent crust. In Utah, near-surface veins and fractures containing mercury are typically associated with iron and base-metal sulfides and gold. Mercury also occurs in replacements along bedding and fracture zones in sediments near porphyry intrusives, and in opalite in volcanic terranes. Small production from presently marginal deposits in province 8 in central Arizona are located in faulted Precambrian schist associated with gold, tungsten, and copper deposits.

Province 3, which includes deposits in the Terlingua district, Texas (type B), has produced moderate amounts of mercury and may contain unknown additional resources. The Terlingua deposits occur in fractures at the contact of intrusive rocks and shale, along hydrothermally altered contacts of clay and limestone formations, in veins, sometimes filling solution caves and fault breccia zones in limestone. These occurrences are associated with Tertiary volcanism and basaltic to rhyolitic intrusives in the Cordilleran belt, possibly close to the old continent margin.

Province 10 in Arkansas also has had a small production from small ore bodies, and the future resource is probably also limited. The deposits are localized in pipelike bodies at fault intersections, parallel to bedding, and as disseminations in sandstone. In contrast, the production of byproduct mercury from zinc mining in northern New York may represent a new province type in eastern United States; hence, it is tentatively included here as province 11.

The search for information about the distribution of noncinnabar mercury localities is incomplete; those mapped are but a preliminary sample whose locations in most cases provides a pattern along the eastern edge of the old continent in the Appalachian belt, and in volcanogenic oceanic crust in northeastern Maine, which resembles the cinnabar distribution in the western Cordilleran belt. There is an overlap of geologic types of occurrence in some regions; coal, shales, limestone, soils, and sphalerite (sulfide) localities occur in the same general area in central Pennsylvania, for example. None of the localities shown with a plus symbol contain economic materials; however, some may have future byproduct potential, if recovered. Joensure (1971) listed 22 coal localities having an average mercury content of 3.3 ppm. Thirty-five sphalerite deposits or occurrences contain more than 1,000 ppb mercury up to 300,000 ppb (Jolly and Heyl, 1968). According to Lovering and others (1966) jasperoids from 22 areas, including 14 mining districts, contained as much as 90 ppm mercury. The sedimentary rocks sampled by McNeal and Rose (1974) contained on the average from 7 to 23 ppb mercury. The nearby soils contained generally larger amounts than the source sedimentary rocks, suggesting that atmospheric mercury may be a contaminant. Donnell and Shaw (1977) found small amounts of mercury in oil shales in Utah and Wyoming, which could be recovered.

Thus, as a geochemical constituent mercury is more widespread in the conterminous United States than the distribution of cinnabar alone might indicate. This suggests to me that much more geologic information about the distribution of mercury is warranted in order to evaluate its total resource possibilities.

Table 1.--*Location, types of deposits, estimates of resource potential, and status of geologic resource knowledge of mercury provinces in the conterminous United States*

Province No.	State	Area	Geologic types of deposits[1]	Preliminary estimates of resource potential[2]: High	Medium	Low	Status of geologic resource information: Adequate	Insufficient
1	Nevada, southeast Oregon, and eastern California	Western Basin and Range, east of Sierra Nevada batholith	II, III, IV	X	--	--	--	X
2	California	Coast Ranges and Sierra foothills	I, III	X	--	--	--	X
3	Southwest Texas	Terlingua district	IV	--	X	--	X	--
4	Southwest Oregon and northern California	Klamath Mountains	I, II	--	X	--	X?	--
5	Central and southern Oregon and northeast California	Crook and Lake Counties	II, IV	--	X	--	--	X
6	East Oregon and western Idaho		I, IV	--	X?	--	--	X
7	Utah, Idaho, Nevada, and California	Eastern edge Basin and Range (widely disseminated)	IV	--	--	X	X	--
8	Arizona	Mazatzal Mountains	IV	--	--	X	--	X
9a	Washington	Olympic Peninsula	Coproduct manganese deposits	--	--	X	--	X
9b	Do	Westside Cascade Range	IV	--	--	X	--	X
9c	Do	Eastside Cascade Range	IV	--	--	X	--	X
10	Arkansas	Pike County	IV	--	--	X	--	X
11?	New York	Adirondack Mountains	Byproduct of Zn deposits	--	X?	--	--	X

[1]Classification of geologic types of deposits and occurrences based on Bailey (1962 and 1964a):

I. Open-space filling, veins and replacements in silica-carbonate (altered serpentine) or faulted eugeosynclinal and volcanogenic sediments and intrusive ophiolitic rocks.

II. Open-space filling and replacement in faulted argillized volcanic flows and breccias, and veinlets and disseminations in opalite (silicified rhyolitic tuff).

III. Open-space filling from hydrothermal solutions and vapors in and around hot springs.

IV. Cavity filling and replacement in faulted and (or) brecciated limestone or clastic sedimentary and metamorphic rocks associated with intrusive or volcanic rocks.

[2]A __high__ estimate indicates the presence or expectation of more than one large (type A or B) deposits; a __low__ estimate is based on the presence of type C deposits and (or) occurrences alone.

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Background information relating to this map and others in the Atlas of Metal and Nonmetal Provinces in the Conterminous United States is published as U.S. Geological Survey Circular 792 (Tooker, 1979), available free of charge from the U.S. Geological Survey, Branch of Distribution, 1200 Eads St., Arlington, VA 22202.

This report is preliminary and has not been edited or reviewed for conformity with Geological Survey standards and nomenclature.