WHITE MOUNTAIN G-E-M
RESOURCES AREA

(GRA NO. CA-04)

TECHNICAL REPORT

(WSA CA 010-075)

Contract YA-553-RFP2-1054

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ATTACHMENTS
(At End of Report)

CLAIM AND LEASE MAPS

Patented/Unpatented

MINERAL OCCURRENCE AND LAND CLASSIFICATION MAPS (Attached)

Metallic Minerals

Uranium and Thorium

Nonmetallic Minerals

Geothermal

LEVEL OF CONFIDENCE SCHEME

CLASSIFICATION SCHEME

MAJOR STRATIGRAPHIC AND TIME DIVISIONS IN USE BY THE U.S. GEOLOGICAL SURVEY

EXECUTIVE SUMMARY

The White Mountain Geology-Energy-Minerals (GEM) Resource Area (GRA) is a narrow strip along the west front of the White Mountains from near Bishop 35 miles northward to beyond the town of Benton. Wilderness Study Area (WSA) CA 010-075, the only WSA in the GRA, consists of nine very small tracts strung along this length of the mountain front.

Much of the GRA, and most of the interior of the mountain range in this area, is underlain by granitic rocks about 90 million to 150 million years old. Along the range front, however, there are remnants of metamorphosed sediments and volcanic rock 150 million to 600 million years old that the granite is intruded into, and these rocks underlie most of the segments of the WSA. At the south end of the GRA the granite is absent and the rocks are sediments about 500 million years old. Metallic mineralization and some of the nonmetallics are related to the granitic intrusions.

Near the north end of the GRA is the Montgomery Canyon mining district, which together with an unnamed mining area a couple of miles north, has produced probably not more than $100,000 in silver and base metals. Other small mines and prospects, mostly gold producers, are scattered along the range front southward. Substantial quantities of nonmetallic minerals -- andalusite, sillimanite and pyrophyllite -- have been produced near the middle of the GRA, and substantial quantities of pumice have been produced from the southern part.

There are patented claims in the Montgomery Canyon. There are at least a couple of hundred unpatented claims, mostly in the southern part of the GRA and some of them in segments of the WSA.

The northernmost segment of WSA CA 010-075 has high favorability with moderate confidence for silver and base metals, and two of the southern segments have high favorability with high confidence for gold because mines lie within them; the other segments have low favorability with low confidence for metallic minerals. All segments of the WSA have low favorability for uranium and thorium, with low confidence. Part of the southernmost segment has high favorability for pumice with high confidence, while the other segments all have low favorability for nonmetallic minerals with low confidence. Most of the segments have moderate favorability for geothermal resources, with moderate confidence, while a few small parts have only low favorability for geothermal resources. All segments of the WSA have very low favorability for oil and gas and for sodium and potassium, with high confidence.

No additional work is recommended for the WSA.

I. INTRODUCTION

The White Mountain G-E-M Resources Area (GRA No. CA-04) contains approximately 92,000 acres (373 sq km) and includes the following Wilderness Study Area (WSA):

WSA Name	WSA Number
White Mountain	010-075

The GRA is located in California in the Bureau of Land Management's (BLM) Bishop Resource Area, Bakersfield district. Figure 1 is an index map showing the location of the GRA. WSA 010-075 consists of a series of very small tracts along a 35-mile stretch of the west foot of the White Mountains. Because the tracts are so small and widely separated, we have assigned each tract or segment a letter designation, beginning with Z for the northernmost and descending down the alphabet to R for the southernmost, in order to be able to refer to them easily. These designations are shown on Figure 2 and on other maps of the GRA. The area encompassed by the GRA is near 37°45' north latitude, 118°20' west longitude and includes the following townships:

T 1 S, R 32,33 E
T 4 S, R 32,33 E
T 2 S, R 32,33 E
T 5 S, R 33,34 E
T 3 S, R 32,33 E
T 6 S, R 33,34 E

The areas of the WSA are on the following U. S. Geological Survey topographic maps:

15-minute:

Benton (NV)
Bishop
White Mountain Peak

The nearest towns are Benton and Bishop, which are located west and southwest of the GRA respectively. Access to the area is via U.S. Highway 6 north. Access within the area is along numerous east-west trending unimproved roads that reach a short way up the western slope of the White Mountains.

Figure 2 outlines the boundaries of the GRA and the WSA on a topographic base at a scale of 1:250,000.

Figure 3 is a geologic map of the GRA and vicinity, also at 1:250,000. At the end of the report, following the Land Classification Maps, is a geologic time scale showing the various geologic eras, periods and epochs by name as they are used in the text, with the corresponding age in years. This is so that the reader who is not familiar with geologic time subdivisions will have a comprehensive reference for the geochronology of events.

This GRA Report is one of fifty-five reports on the Geology-Energy-Minerals potential of Wilderness Study Areas in the Basin and Range Province, prepared for the Bureau of Land Management by the Great Basin GEM Joint Venture.

The principals of the Venture are Arthur Baker III, G. Martin Booth III, and Dennis P. Bryan. The study is principally a literature search supplemented by information provided by claim owners, other individuals with knowledge of some areas, and both specific and general experience of the authors. Brief field verification work was conducted on approximately 25 percent of the WSAs covered by the study.

The WSA in this GRA was not field checked.

One original copy of background data specifically applicable to this GEM Resource Area Report has been provided to the BLM as the GRA File. In the GRA File are items such as letters from or notes on telephone conversations with claim owners in the GRA or the WSA, plots of areas of Land Classification for Mineral Resources on maps at larger scale than those that accompany this report if such were made, original compilations of mining claim distribution, any copies of journal articles or other documents that were acquired during the research, and other notes as are deemed applicable by the authors.

As a part of the contract that resulted in this report, a background document was also written: Geological Environments of Energy and Mineral Resources. A copy of this document is included with the GRA File to this GRA report. There are some geological environments that are known to be favorable for certain kinds of mineral deposits, while other environments are known to be much less favorable. In many instances conclusions as to the favorability of areas for the accumulation of mineral resources, drawn in these GRA Reports, have been influenced by the geology of the areas, regardless of whether occurrences of valuable minerals are known to be present. This document is provided to give the reader some understanding of at least the most importnat aspects of geological environments that were in the minds of the authors when they wrote these reports.

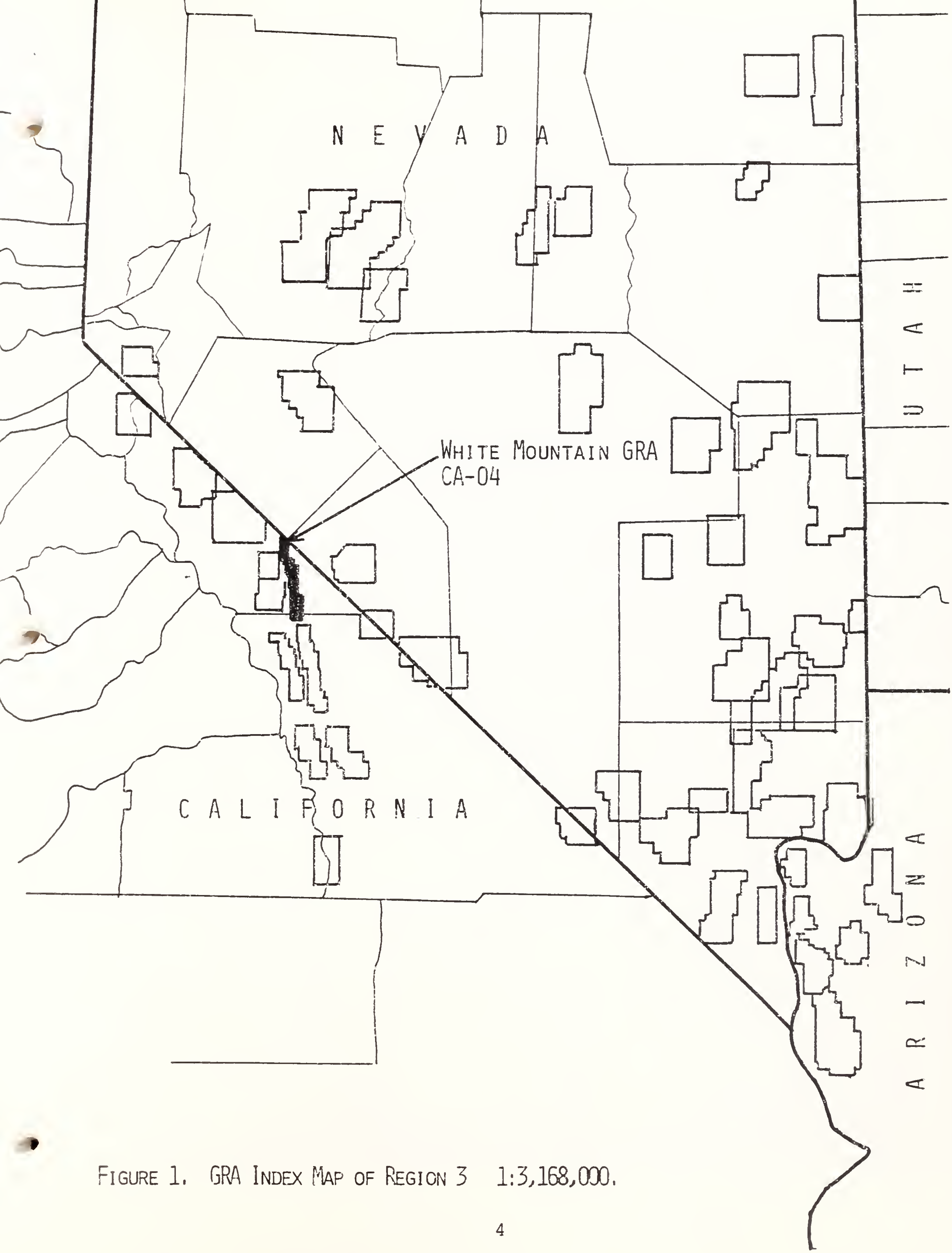
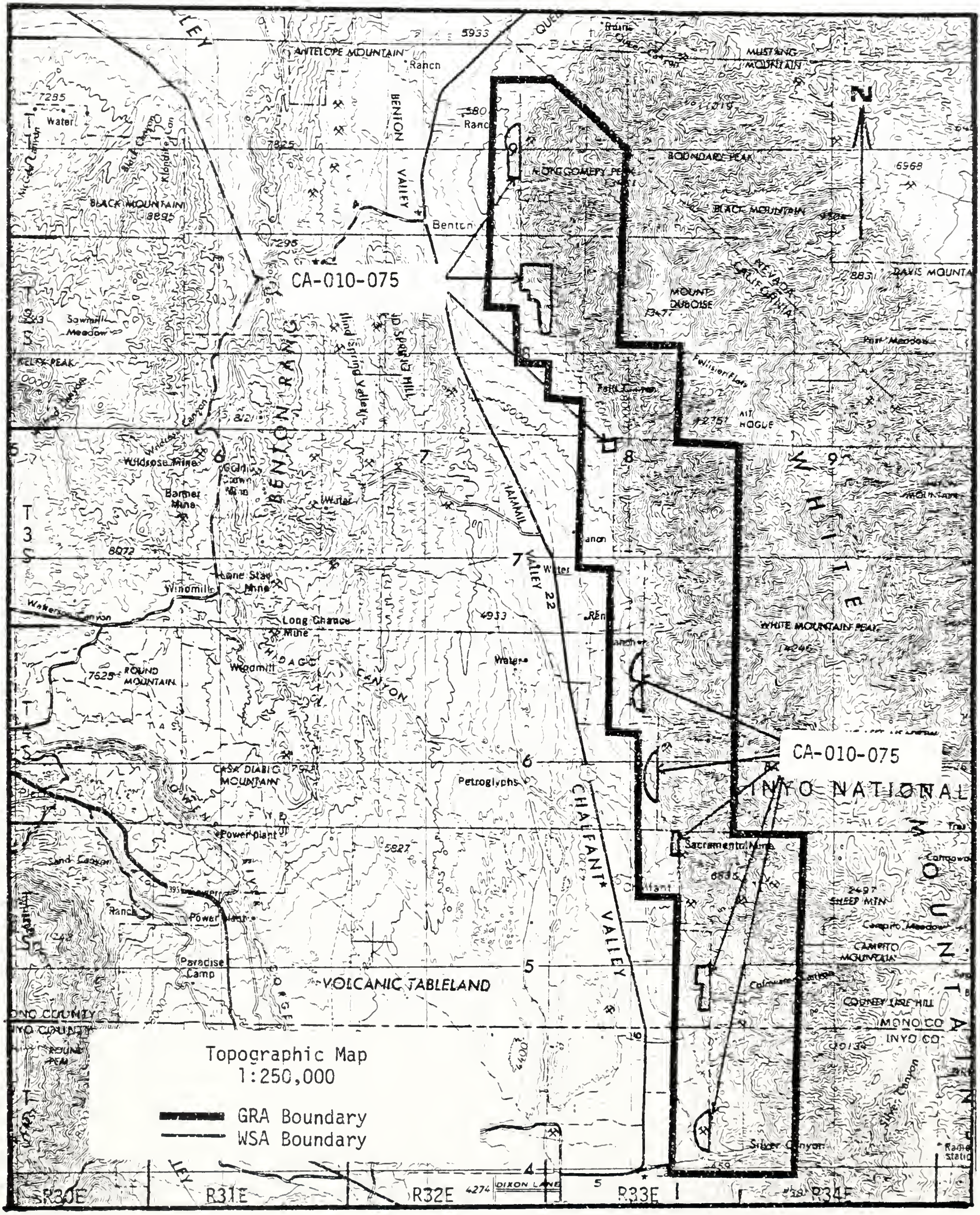


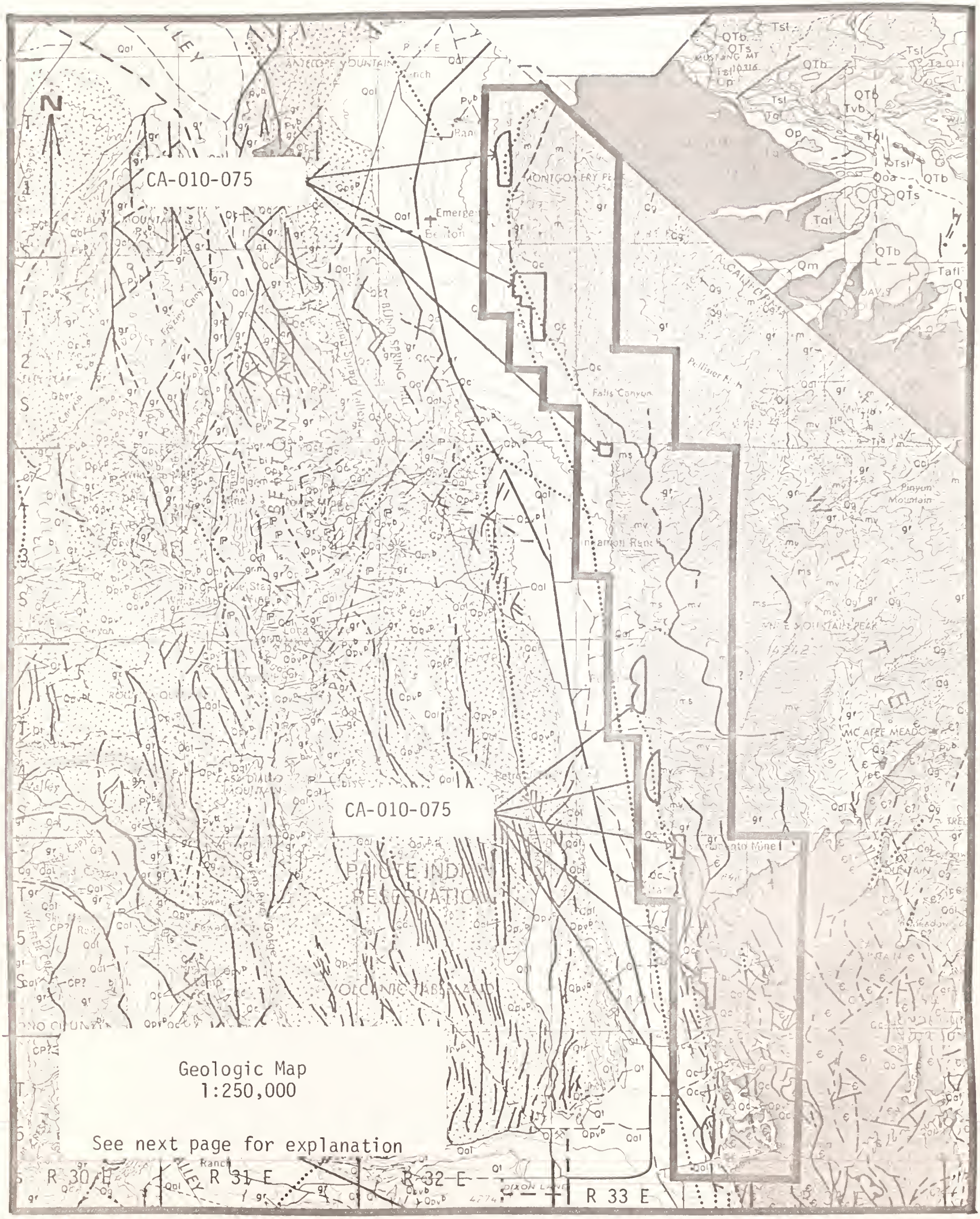
Figure 1. GRA Index Map of Region 3 1:3,168,000.



Mariposa Sheet

White Mountain GRA CA-04

Figure 2



Mariposa Sheet, Strand (1967); Mineral County Geologic Map, Ross (1961)

White Mountain GRA CA-04

Figure 3

EXPLANATION

Era	Period	Epoch	Symbol	SEDIMENTARY AND METASEDIMENTARY ROCKS		Symbol	IGNEOUS AND META-IGNEOUS ROCKS
CENOZOIC	QUATERNARY	*Recent*	Qs	Dune sand			
			Qal	Alluvium			
			Qsc	Stream channel deposits	GREAT VALLEY	Qrv	Recent volcanic: Qrv^r —rhyolite; Qrv^a —andesite; Qrv^b —basalt; Qrv^p —pyroclastic rocks
			Qf	Fan deposits			
			Qb	Basin deposits			
			Qst	Salt deposits			
			Ql	Quaternary lake deposits			
		Pleistocene	Qg	Glacial deposits			
			Qt	Quaternary nonmarine terrace deposits			
			Qm	Pleistocene marine and marine terrace deposits		Qpv	Pleistocene volcanic: Qpv^r —rhyolite; Qpv^a—andesite; Qpv^b —basalt; Qpv^p —pyroclastic rocks
			Qc	Pleistocene nonmarine			
			QP	Plio-Pleistocene nonmarine		✳	Quaternary and/or Pliocene cinder cones
	TERTIARY	*Pliocene*	Pc	Undivided Pliocene nonmarine			
			Puc	Upper Pliocene nonmarine			
			Pu	Upper Pliocene marine		Pv	Pliocene volcanic: Pv^r —rhyolite; Pv^a—andesite; Pv^b —basalt; Pv^p —pyroclastic rocks
			Pmlc	Middle and/or lower Pliocene nonmarine			
			Pml	Middle and/or lower Pliocene marine			
		Miocene	Mc	Undivided Miocene nonmarine			
			Muc	Upper Miocene nonmarine			
			Mu	Upper Miocene marine		Mv	Miocene volcanic: Mv^r —rhyolite; Mv^a —andesite; Mv^b —basalt; Mv^p —pyroclastic rocks
			Mmc	Middle Miocene nonmarine			
			Mm	Middle Miocene marine			
			Ml	Lower Miocene marine			
		Oligocene	Φc	Oligocene nonmarine		Φv	Oligocene volcanic: $Φv^r$—rhyolite; $Φv^a$ —andesite; $Φv^b$ —basalt; $Φv^p$ —pyroclastic rocks
			Φ	Oligocene marine			
		Eocene	Ec	Eocene nonmarine		Ev	Eocene volcanic: Ev^r —rhyolite; Ev^a —andesite; Ev^b —basalt; Ev^p —pyroclastic rocks
			E	Eocene marine			
		Paleocene	Epc	Paleocene nonmarine			
			Ep	Paleocene marine			

EXPLANATION CONT.

	Pa	Ep	Paleocene marine		
	Undivided	QTc	Cenozoic nonmarine	QTv	Cenozoic volcanic: QTvr —rhyolite; QTva —andesite; QTvb —basalt; QTvp —pyroclastic rocks
		Tc	Tertiary nonmarine	Tgr	Tertiary granitic rocks
		Tl	Tertiary lake deposits	Ti	Tertiary intrusive (hypabyssal) rocks: Tir – rhyolite, Tia – andesite; Tib – basalt
		Tm	Tertiary marine	Tv	Tertiary volcanic: Tvr —rhyolite; Tva —andesite; Tvb —basalt; Tvp —pyroclastic rocks
MESOZOIC	CRETACEOUS	K	Undivided Cretaceous marine		
		Ku	Upper Cretaceous marine	KJf (Franciscan Formation)	
		Kl	Lower Cretaceous marine	KJfv	Franciscan volcanic and metavolcanic rocks
	JURASSIC	Jk	Knoxville Formation	gr	Mesozoic granitic rocks: grg-granite and adamellite; grg-granodiorite; grt-tonalite and diorite
		Ju	Upper Jurassic marine	bi	Mesozoic basic intrusive rocks
		Jml	Middle and/or Lower Jurassic marine	ub	Mesozoic ultrabasic intrusive rocks
	TRIASSIC	℞	Triassic marine	J℞v	Jura-Trias metavolcanic rocks
	UNDIVIDED	m ls	Pre-Cretaceous metamorphic rocks (ls = limestone or dolomite)	mv	Pre-Cretaceous metavolcanic rocks
		ms	Pre-Cretaceous metasedimentary rocks	gr-m	Pre-Cenozoic granitic and metamorphic rocks
PALEOZOIC		P ls	Paleozoic marine (ls = limestone or dolomite	Pv	Paleozoic metavolcanic rocks
	PERMIAN	P	Permian marine	Pv	Permian metavolcanic rocks
	CARBONIFEROUS	C	Undivided Carboniferous marine	Cv	Carboniferous metavolcanic rocks
		CP	Pennsylvanian marine		
		CM	Mississippian marine		
	DEVONIAN	D	Devonian marine	Dv	Devonian metavolcanic rocks
	SILURIAN	S	Silurian marine	Dv?	Devonian and pre-Devonian? metavolcanic rocks
		pSs	Pre-Silurian metasedimentary rocks	pS	Pre-Silurian metamorphic rocks
				pSv	Pre-Silurian metavolcanic rocks
	ORDOVICIAN	O	Ordovician marine		
	CAMBRIAN	€	Cambrian marine		
		€?	Cambrian – Precambrian marine	p€c	Precambrian igneous and metamorphic rock complex
PRECAMBRIAN		p€	Undivided Precambrian metamorphic rocks p€g = gneiss, p€s = schist	p€gr	Undivided Precambrian granitic rocks
		lp€	Later Precambrian sedimentary and metamorphic rocks	p€an	Precambrian anorthosite
		ep€	Earlier Precambrian metamorphic rocks		

II. GEOLOGY

The White Mountain GRA follows the north-northwest trending western escarpment of the White Mountains from several miles north of Montgomery Peak in eastern Mono County southward to Silver Canyon in Inyo County. The White Mountains are a large east tilted fault block consisting of a granitic core flanked by a belt of metamorphic, sedimentary and volcanic rocks.

The oldest structures preserved in the study area are pre-Cretaceous faults and planes of weakness which acted as conduits for late stage mineral bearing fluids and dike material migrating from cooling Jurassic intrusives. Except for pumice deposits, all ore deposits within the study area are genetically related to the Jurassic intrusives. Deposits of andalusite, pyrophyllite, silver and base metals, and gold have been mined in the study area.

The most prominent structures in the area are the late Pliocene Basin and Range faults which are still active today. Current tectonism is shown by the displacement of recent sediments in the southern portion of the study area.

Both flooding and earthquakes pose environmental dangers within the White Mountain GRA.

1. PHYSIOGRAPHY

The area of study is mostly in eastern Mono County with the southern boundary extending several miles into Inyo County. The White Mountain GRA is a long rectilinear area which follows the north-northwest trending escarpment of the White Mountains from several miles north of Montgomery Peak to Silver Canyon in the south. The range lies on the western border of the desert region of the Great Basin along the California-Nevada border.

The White Mountains are a large east tilted fault block consisting of a granitic core flanked by a belt of metamorphic sedimentary and volcanic rocks. The average elevation of the crest ranges from 10,000-13,000 feet with the highest point of 14,246 feet at White Mountain Peak. The crest of the range is close to the precipitous western margin with resultant steep stream gradients. Canyons are closely spaced and give the visual impression of physiographic youth. Large alluvial fans record the frequent flooding which poses a potential environmental danger. Hamill and Chalfant valleys, into which the canyons debouch, are at an elevation of about 4,500 feet.

2. ROCK UNITS

The oldest rocks in the White Mountain GRA are Cambrian marine sediments and metasediments of the Poleta and Campito Formations which are predominantly hornfels and marble beds. These comprise a large portion of the southern end of the study area (Bateman, 1965) and several patches and strips of Cambrian marble lie along the range front in the northern portion (Crowder and Sheridan, 1972).

Triassic-Jurassic meta-volcanics form the White Mountain escarpment in the central portion of the study area. These felsic and mafic volcanics have been metamorphosed by several Jurassic intrusions -- Mt. Barcroft granodiorite in the southern portion and adamellite and granite of Pellisier Flats in the northern portion of the study area. In the middle of T 3 S, R 33 E a unit of mixed metamorphic and granitic rocks represents a meta-volcanic terrane that was altered and albitized by emanations from the Pellisier Flats intrusive and younger Cretaceous bodies (Crowder and others, 1972).

Aplite and aphanitic dikes related to the cooling intrusions were emplaced along structures during the Cretaceous.

Volcanism in the Quaternary resulted in the deposition of the Bishop Tuff. Near the Sacramento Mine is the northernmost splatter of pumice and air-fall ash along the White Mountain front, and larger deposits lie along the range-front farther south (Dalrymple and others, 1965). Some of these pumice deposits have been mined.

Approximately eight miles southeast of Benton along the range front are several small remnants of a Pleistocene glacial deposit.

3. STRUCTURAL GEOLOGY AND TECTONICS

The oldest structures preserved in the study area are pre-Cretaceous faults and planes of weakness which acted as conduits for late stage mineral bearing fluids, and dike material migrating from the cooling igneous intrusions.

The White Mountain fault zone is well defined and extends from the north end of the White Mountain GRA south to Milner Creek. This fault zone consists of numerous roughly parallel post-intrusive shears dipping gently to the west. The fault zone appears to die out at Milner Creek and its relation to shear zones and steeply dipping frontal faults to the south is not clear (Crowder and others, 1972).

A belt of smaller young faults along the range front occur south of Milner Creek to the southern limit of the White Mountain GRA. These normal faults, which are down-thrown on the side toward the mountains, in some places expose old alluvial fan deposits (Qoa) in the upthrown blocks. It is interesting to note that no obvious young faults occur along the White Mountain fault zone. The White Mountain fault zone is also in the most precipitous area, however, and active alluviation may have covered young scarps. It has not been resolved whether the lack of young frontal faults represents a significant structural difference or a difference in patterns of alluviation.

4. PALEONTOLOGY

The White Mountain GRA contains Paleozoic and Mesozoic rocks along its eastern part and derived Quaternary clastics along the western margin. Lithology of Mesozoic units (metasedimentary, metavolcanic, and metamorphosed carbonate strata) is not favorable for the preservation of fossils. Paleozoic marine strata, on the other hand, are known to contain an abundant and significant marine fauna from exposures within the Campito and Poleta Formations outside the boundary of the study area. Although no localities are known from the GRA, there is a high potential for paleontological resources from Cambrian and possibly Eocambrian strata.

5. HISTORICAL GEOLOGY

Marine sediments of the Campito and Poleta Formations were deposited during the Cambrian. An unknown sequence of marine sediments were deposited over them throughout the Paleozoic. A period of nondeposition followed.

Unnamed Triassic-Jurassic volcanics and sediments unconformably overlie the older sediments. During the Jurassic, the large batholithic intrusions of Mt. Barcroft granodiorite, and Pellisier Flats adamellite and granite completely metamorphosed the Paleozoic and Mesozoic sediments and volcanics. Fluids from the late stage of cooling of these intrusions migrated along structures and formed the ore bodies within the study area.

Basin and Range faulting occurred during the Pliocene and is still active as evidenced by minor displacement and uplift of recent sediments.

Subsequent to the major Basin and Range displacement, volcanism produced the Quaternary age Bishop Tuff.

A period of glaciation during the late Pleistocene is marked by several small patches of glacial debris along the range front.

III. ENERGY AND MINERAL RESOURCES

A. METALLIC MINERAL RESOURCES

1. Known Mineral Deposits

The Montgomery Canyon district, in about Secs. 24 and 25, T 1 S, R 32 E, at the north end of the district is reported to have produced about $60,000 in silver and base metals in the late 1800s from the Silver Glance, Phoenix and Creekside mines.

Near the southern end of the GRA is the ill-defined Paiute district, which has several mines with rather small production, mostly gold. Among these are: Sacramento in Secs. 2 and 3, T 5 S, R 33 E, Twenty-Grand in Sec. 19, T 5 S, R 34 E, and Southern Belle in Sec. 35, T 5 S, R 33 E. There are also other gold mines that probably have made minor production: Moulas in Sec. 7, T 5 S, R 34 E, and Monaco and Z & S in Sec. 18, T 5 S, R 34 E.

2. Known Prospects, Mineral Occurrences and Mineralized Areas

In the NE 1/4 of Sec. 6, T 3 S, R 33 E is a zigzag bulldozed trail climbing the face of a ridge, prominently visible from U.S. 6. It has been known as the Mountain View, Proctor, and in the mid-1960s as the Mineral Slope mine. Low lead and zinc values are disseminated in shear zones (personal communication, A. Baker III).

Half a mile west of the Twenty-Grand gold mine in the Paiute district is an area about half a mile in diameter in which the Paleozoic sediments are pyrometasomatized and contain local small quantities of copper mineralization and traces of gold. There are several adits and a couple of shafts in this area, driven in the early 1900s. Some inconclusive drilling was done on the property in 1965, and there are reports of an extensive drilling project in the late 1960s (A. Baker III, personal communications).

3. Mining Claims

There are patented claims in the Montgomery Canyon district.

There appear to be at least a couple of hundred unpatented claims in the GRA. One cluster is in the Montgomery Canyon district.

There is a fairly dense cluster of unpatented claims in the Paiute district, a few of them in the vicinity of the Sacramento mine but most of them farther south, perhaps covering all of the known gold and copper occurrences.

4. Mineral Deposit Types

Renken (1980) describes the productive veins of the Montgomery Creek district as mostly quartz veins, but with some replacement in adjacent carbonate rocks, with the ore minerals being originally galena, probably sphalerite, and rare chalcopyrite except in occurrences in quartzite. They are mesothermal, related to one or another of the Mesozoic intrusions in the area. Judging by the limited production, all the known occurrences are quite small -- individually producing perhaps a few hundred tons of ore at most. Some of the early-found ones, at least, must have been very rich.

The Paiute district near the south end of the GRA extends for seven or eight miles along the White Mountain front and four or five miles into the range. Old small mines and prospects are rather sparsely scattered through this area, mostly on gold occurrences but particularly toward the south end on barite and associated lead occurrences. Probably no single mine has produced more than $100,000 in value of any commodity. The gold veins are like those seen at many places in the White Mountains: one foot to three feet of quartz with locally abundant limonite and some copper staining, indicating an original high sulfide content of pyrite, some chalcopyrite, and probably some sphalerite and perhaps galena. They are mesothermal, and no doubt related to the Mesozoic intrusives.

5. Mineral Economics

The small quartz veins that make up most of the metallic mineralization in the district are, in themselves, of minimal importance for modern mining. However, it is possible that at least some of them may indicate the possibility of larger deposits. Renken (1980) thinks there is potential for secondarily enriched copper and silver ore in the Montgomery Creek district. The drilling that has been done in the vicinity of the Twenty Grand mine in the Paiute district apparently was not successful in finding a major ore body but does not necessarily rule out the possibility that one is present.

The major use of gold is for storing wealth. It is no longer used for coinage because of monetary problems, but many gold "coins" are struck each year for sale simply as known quantities of gold that the buyer can keep or dispose of relatively easily. The greatest other use of gold is in jewelry, another form of stored wealth. In recent years industrial applications have become increasingly important, especially as a conductor in electronic instrumentation. In the United States and some other countries gold is measured in troy ounces that weigh 31.1 grams -- twelve of which make one troy pound. Annual world production is about 40 million ounces per year, of which the United States produces somewhat more than one million ounces, less than one-fourth of its consumption, while the Republic of South Africa is by far the largest producer at more than 20 million ounces per year. World production is expected to increase through the 1980s. For many years the price was fixed by the United States at $35 per ounce, but after deregulation the price rose to a high of more than $800 per ounce and then dropped to the neighborhood of $400 per ounce. At the end of 1982 the price was $460.50 per ounce.

The major uses of silver are in photographic film, sterlingware, and increasingly in electrical contacts and conductors. It is also widely used for storage of wealth in the form of jewelry, "coins" or bullion. Like gold it is commonly measured in troy ounces, which weigh 31.1 grand grams, twelve of which make one troy pound. World production is about 350 million ounces per year, of which the United States produces about one-tenth, while it uses more than one-third of world production. About two-thirds of all silver is produced as a byproduct in the mining of other metals, so the supply cannot readily adjust to demand. It is a strategic metal. Demand is expected to increase in the next decades because of growing industrial use. At the end of 1982 the price of silver was $11.70 per ounce.

The largest use for lead is in electrical storage batteries, the second being a gasoline antiknock additive. It has many other uses, however, including radiation shielding, solders, numerous chemical applications, and in construction. About four million metric tons of lead are produced in the world annually. The United States produces about half a million tons per year, and recovers about the same amount from scrap -- much of it through the recycling of old batteries. It imports about one-quarter of a million tons. Lead is classified as a strategic mineral. Demand is projected to increase somewhat in the next couple of decades, but environmental concerns will limit the increase. The United States has large ore reserves that are expected to last well beyond the end of this century at current production rates even without major new discoveries. At the end of 1982 the price was about 22 cents per pound.

B. NONMETALLIC MINERAL RESOURCES

1. Known Mineral Deposits

Near the middle of the GRA is an unnamed industrial minerals district. The Jeffrey mine, in Sec. 10, T 4 S, R 33 E produced relatively large amounts of andalusite and sillimanite in the 1920s and 30s. Rutile is reported present in this area also (Anonymous, undated; and Marsh, 1979).

The Pacific mine, near Lone Tree Canyon in Sec. 32, T 3 S, R 33 E has produced some tens of thousands of tons of pyrophyllite/sericite ore from an open pit since the 1950s. It was operating in 1982. The Colton mine, in Milner Canyon in Sec. 23, T 4 S, R 33 E, produced some hundreds or perhaps thousands of tons of purer pyrophyllite from underground workings around 1960 and perhaps later (A. Baker III, personal communication).

In the southeastern part of the district are barite mines from which some hundreds of tons of production have been made: the most productive is in Gunter Canyon in Sec. 6 T 6 S, R 34 E, with lesser ones in Sec. 33, T 5 S, R 34 E, and in approximately Sec. 5, T 6 S, R 34 E (A. Baker III, personal communication).

On the lowermost slopes of the White Mountains, along and south of Gunter Canyon in Secs. 12 and 13 T 6 S, R 33 E and Secs. 7 and 18, T 6 S, R 34 E, are several pumice deposits that have made some production; at one time the largest of these was held by U.S. Gypsum Co (A. Baker III, personal communication).

In Sec. 3, T 5 S, R 33 E is the Sacramento Canyon pumice deposit, which was mined in 1948 (Chesterman, 1956).

2. Known Prospects, Mineral Occurrences and Mineralized Areas

For a length of about 13 miles, from a couple of miles north of Chalfant to Falls Canyon, the west side of the White Mountains is mostly a series of brilliantly red, yellow and orange stained rocks. The White Mt. Peak geologic map (Crowder & Sheridan, 1972) shows this to be mostly Jurassic metavolcanics and metasediments. The Jeffrey andalusite mine and the Pacific and Colton pyrophyllite mines lie in the southern part of this terrane. A traverse part way up Lone Tree Canyon, near the Pacific mine, indicates that these rocks have nearly everywhere a small content of pyrite, locally with traces of copper, and in places stringers of magnetite parallel to schistosity (A. Baker III, personal communication). A deposit of melanterite (iron sulfate) near the mouth of

Lone Tree Canyon may be a secondary product of the weathering of this pyrite.

3. Mining Claims, Leases and Material Sites

Patented claims in four sections about in the middle of the GRA may cover the Jeffrey mine. Patented claims in two sections in the southern part of the GRA may cover some of the pumice deposits in this area.

There are three clusters of claims in the area of brilliantly-colored metavolcanics and metasediments, one near the north end, one near the middle, and one near the south end. The middle and southern ones may cover the known andalusite and pyrophyllite mines and surrounding ground. Within the limits of our plotting, most of them seem to be in extremely rugged terrain, suggesting that someone is pretty serious about them.

Some of the unpatented claims in the southern part of the GRA probably cover barite occurrences and perhaps some of the pumice deposits.

4. Mineral Deposit Types

The andalusite and pyrophyllite deposits near the middle of the district were formed by high-temperature hydrothermal alteration of Jurassic volcanic rocks resulting from the intrusion of the somewhat younger Jurassic granitic bodies. The northern two deposits lie within the White Mountain fault zone, and the Colton deposit lies along its projection, suggesting that concommitant shearing of the fault zone, which appears to be at least older than Cretaceous (Crowder and Sheridan, 1972), may have been an important factor in the development of these unusually large bodies of rather uncommon minerals.

Some of the barite occurrences near Gunter Canyon in the south end of the district are clearly fissure-filling veins in shales, but others are bedded deposits in limestone. It seems possible that this area is an extension of the province of bedded barite deposits that extends from northern Nevada diagonally across the State in this direction, and that in part the barite has been remobilized by mesothermal mineralizing solutions to form the vein occurrences.

The pumice deposits in the southern part of the GRA are remnants of a 20-foot thick bed of pumice deposited during the eruption of the Quaternary Bishop Tuff. That the pumice is of good quality for at least some uses is demonstrated by the fact that some thousands of tons were shipped in the early 1900s from deposits in this GRA and on the west side of Owens Valley. Presumably the deposit that has been held by U.S. Gypsum has been proved to be of substantial size; there is no information at all about the other deposits.

5. Mineral Economics

The Jeffrey andalusite deposit has not been mined for about forty years, because synthetic refractories took the place of the natural material. The Pacific pyrophyllite mine continues to operate, its product being shipped to the Los Angeles area. Both minerals are uncommon, and substantial deposits of them are even more uncommon. It can be presumed that special qualities of the pyrophyllite are responsible for the fact that it can stand the high transportation cost to market, while more common nonmetallic minerals in the region are priced out of most markets by transportation costs. It is possible that there are other industrial minerals in this geologically unusual area that are uncommon enough to be economic.

There are several major varieties of clay, differing both in their mineralogy and their uses, and some materials that mineralogically are clay are called by other names, while some that technically are not clay are called clay. Large amounts of white clay (kaolin) are used as filler in paper to produce the glossy sheen of magazine pages. Even larger quantities of common clay are used in making bricks, drain tile, and other construction products. Certain clays are used extensively in ceramics and in refractory materials. Minor uses include drilling muds, foundry sands, purifying materials for oils, and a great many more. The United States uses about 50 million tons of clays annually, nearly all of it produced domestically. Consumption is forecast to about double by the year 2000, with production increasing in amount the same proportion. The price of clay varies widely depending on the kind of material: the average price is a little lower than $20 per ton, but common clay is valued at about $5 per ton while the highest-priced clay, kaolin, averages about $65 per ton.

More than 90% of all barite mined is used to make mud for oil and gas well drilling, where the high specific gravity, softness and chemical inertness of the mineral are essential characteristics. Other uses of barite are in barium chemicals that have a wide variety of applications. In recent years the United States has used nearly three million tons of barite annually; usage fluctuates with oil and gas drilling activity. Domestic sources produced about two-thirds of the barite used, with Nevada being by far the largest producer. Most imported barite is used in the states near the Gulf of Mexico, where shipping costs by sea from foreign sources are lower than rail transportation costs from Nevada. Barite consumption in the United States is forecast to be about the same in the year 2000 as it presently is, although this will depend largely on oil and gas drilling activity and the forecast may be greatly in error. Domestic production is expected to continue to satisfy about two-thirds of the demand. The price for crude barite is about $25 per ton, while crushed and ground barite ready for use as drilling mud is about $50 per ton.

For statistical purposes pumice, volcanic cinder and scoria are treated together because in most applications they are interchangeable; the word "pumice" as used here includes the other materials. Because of its porous nature and resultant light weight (some pumice will float on water), about 40% of all pumice production is used as aggregate in making light-weight concrete for construction purposes. An equal amount is used as aggregate in road construction. A small amount is used in abrasives, while the remainder is used, mostly in finely-ground form, in a multitude of applications such as absorbents, carriers for insecticides, decolorizers and purifying agents, fillers and extenders for paints, and many others. United States consumption is about 4.5 million short tons annually, nearly all of which is produced domestically and most of which is produced within a very few hundred miles of the point of use because it is a high-volume, low-unit-price material. A small quantity of pumice for specialized uses is imported. United States demand for pumice is forecast to more than double by the year 2000, with domestic production keeping up with demand. In recent years the F.O.B. mine price for pumice as such has been about $4 per ton, while the price for the somewhat more common volcanic cinders has been about $3 per ton.

C. ENERGY RESOURCES

Uranium and Thorium Resources

1. Known Mineral Deposits

There are no known uranium or thorium deposits within or near the WSAs or the GRA.

2. Known Prospects, Mineral Occurrences and Mineralized Areas

Known radioactive occurrences are indicated on the Uranium Land Classification and Mineral Occurrence Map included at the back of the report.

There is one uranium occurrence within the GRA, though it is not within the WSA. This occurrence is at the Claw claim, Sec. 32(?), T 2 S, R 33 E (Minobras, 1978), but the type of occurrence is not described in the literature.

There are no other uranium or thorium occurrences within or near the WSAs or the GRA.

3. Mining Claims

The Claw Claim is the only known uranium claim within the GRA, and it has probably lapsed. There are no known thorium leases.

4. Mineral Deposit Types

Deposit types can't be discussed for the GRA due to the lack of uranium and thorium occurrences.

5. Mineral Economics

Uranium and thorium would appear to be uneconomic for the GRA area due to the lack of occurrences. However, this may merely indicate a lack of exploration for these minerals in the area.

Uranium in its enriched form is used primarily as fuel for nuclear reactors, with lesser amounts being used in the manufacture of atomic weapons and materials which are used for medical radiation treatments. Annual western world production of uranium concentrates totaled approximately 57,000 tons in 1981, and the United States was responsible for about 30 percent of this total, making the United States the largest single producer of uranium (American Bureau of Metal Statistics Inc., 1982). The United States ranks second behind Australia in uranium resources based on a production cost of $25/pound or less. United States uranium demand is growing at a much slower rate than was forecast in the late 1970s, because the number of new reactors scheduled for construction has declined sharply since the accident at the Three Mile Island Nuclear Plant in March, 1979. Current and future supplies were seen to exceed future demand by a significant margin and spot prices of uranium fell from $40/pound to $25/pound from January, 1980 to January, 1981 (Mining Journal, July 24, 1981). At present the outlook for the United States uranium industry is bleak. Low prices and overproduction in the industry have resulted in the closures of numerous uranium mines and mills and reduced production at properties which have remained in operation. The price of uranium at the end of 1982 was $19.75/pound of concentrate.

Thorium is used in the manufacture of incandescent gas mantles, welding rods, refractories, as fuel for nuclear power reactors and as an alloying agent. The principal source of thorium is monazite which is recovered as a byproduct of titanium, zirconium and rare earth recovery from beach sands. Although monazite is produced from Florida beach sands, thorium products are not produced from monazite in the United States. Consequently, thorium products used in the United States come from imports, primarily from France and Canada, and industry and government stocks. Estimated United States consumption of thorium in 1980 was 33 tons, most of which was used in incandescent lamp mantles and refractories (Kirk, 1980b). Use of thorium as nuclear fuel is relatively small at present, because only two commercial thorium-fueled reactors are in operation. Annual United States demand for thorium is projected at 155 tons by 2000 (Kirk, 1980a). Most of this growth is forecast to occur in nuclear power reactor usage, assuming that six to ten thorium-fueled reactors are on line by that time. The United States and the rest of the world are in a favorable position with regard to adequacy of thorium reserves. The United States has reserves estimated at 218,000 tons of ThO_2 in stream and beach placers, veins and carbonatite deposits (Kirk, 1982); and probable cumulative demand in the United States as of 2000 is estimated at only 1800 tons (Kirk, 1980b). The price of thorium oxide at the end of 1981 was $16.45 per pound.

Oil and Gas Resources

There are no oil and gas fields, hydrocarbon shows in wells, or surface seeps in the region; nor are there any Federal oil and gas leases in the immediate region. The terrane of metamorphic and intrusive rocks, and very Early Cambrian rocks at the south end of the GRA, is not favorable for oil and gas resources; that is, there are no source beds present. There is no oil and gas lease map, nor is there an oil and gas occurrence map included in this report.

Geothermal Resources

1. Known Geothermal Deposits

There are no known deposits present.

2. Known Prospects, Geothermal Occurrences, and Geothermal Areas.

There is no recorded direct evidence of geothermal resources within the White Mountain GRA. Across the valley at the northern end of the GRA are two hot springs:

the 57°C Benton Hot Springs which has low salinity water (320 mg/l) and flows at a rate of 800 l/min, and Bertrand Ranch Springs which flows 21°C water at 380 l/min (NOAA, 1980).

Fifteen miles to the west and normal to the structural grain of the Basin and Range is the east-west elliptical Long Valley collapsed caldera. This geothermal resource is considered highly prospective by exploration companies, academia, and by the U.S. Geological Survey which has designated most of the area a KGRA. The eastern extremity of the Pliocene/Pleistocene volcanics encompassing Mono-Long Valley and surrounding geothermal resource areas, appears to be the Chalfant Valley structural dislocation. The White Mountain GRA straddles the far eastern segment of this fault zone.

3. Geothermal Leases

There are no Federal geothermal leases or lease applications in the region. No geothermal lease map has been included with this report.

4. Geothermal Deposit Types

There are no geothermal resources known to exist within the GRA.

5. Geothermal Economics

Although Benton Hot Springs has a local potential for development of geothermal resources for direct use, there are no thermal resources of record in the White Mountain GRA.

Geothermal resources are utilized in the form of hot water or steam normally captured by means of drilling wells to a depth of a few feet to over 10,000 feet in depth. The fluid temperature, sustained flow rate and water chemistry characteristics of a geothermal reservoir determine the depth to which it will be economically feasible to drill and develop each site.

Higher temperature resources (above 350°F) are currently being used to generate electrical power in Utah and California, and in a number of foreign countries. As fuel costs rise and technology improves, the lower temperature limit for power will decrease appreciably -- especially for remote sites.

All thermal waters can be beneficially used in some way, including fish farming (68°F), warm water for year around mining in cold climates (86°F), residential space heating (122°F), greenhouses by space heating (176°F), drying of vegetables (212°F), extraction of salts by evaporation and crystallization (266°F), and drying of diatomaceous earth (338°F).

Unlike most mineral commodities remoteness of resource location is not a drawback. Domestic and commercial use of natural thermal springs and shallow wells in the Basin and Range province is a historical fact for over 100 years.

Development and maintenance of a resource for beneficial use may mean no dollars or hundreds of millions of dollars, depending on the resource characteristics, the end use and the intensity or level of use.

D. OTHER GEOLOGICAL RESOURCES

No other geological resources were identified in the White Mountain GRA.

E. STRATEGIC AND CRITICAL MINERALS AND METALS

A list of strategic and critical minerals and metals provided by the BLM was used as a guideline for the discussion of strategic and critical materials in this report.

The Stockpile Report to the Congress, October 1981-March 1982, states that the term "strategic and critical materials" refers to materials that would be needed to supply the industrial, military and essential civilian needs of the United States during a national emergency and are not found or produced in the United States in sufficient quantities to meet such need. The report does not define a distinction between strategic and critical minerals.

Lead, a strategic metal, has been produced in small quantities as a byproduct of silver production in the GRA.

IV. LAND CLASSIFICATION FOR G-E-M RESOURCES POTENTIAL

The geologic maps at 1:62,500 scale by Crowder and others (1972), Crowder and Sheridan (1972), and Bateman (1965) provide excellent geological coverage of the GRA except for the lack of mapping of hydrothermal alteration if it is present. At the south end of the GRA Bateman (1956) provides good data on mineral occurrences, which is supplemented in this area and elsewhere by private communications, again with the exception of data o hydrothermal alteration. There is no geochemical data. Geological information available for the GRA is ample and of high quality, and mineral occurrences data is sufficient and of good quality. Overall, the level of confidence in data available is high.

Land classification areas are numbered starting with the number 1 in each category of resources. Metallic mineral land classification areas have the prefix M, e.g. M1-4D. Uranium and thorium areas have the prefix U. Nonmetallic mineral areas have the prefix N. Oil and gas areas have the prefix OG. Geothermal areas have the prefix G. Sodium and potassium areas have the prefix S. The saleable resources are classified under the nonmetallic mineral resource section. Both the Classification Scheme, numbers 1 through 4, and the Level of Confidence Scheme, letters A, B, C, and D, as supplied by the BLM are included as attachments to this report. These schemes were used as strict guidelines in developing the mineral classification areas used in this report.

Land classifications have been made here only for the areas that encompass segments of the WSA. Where data outside a WSA has been used in establishing a classification area within a WSA, then at least a part of the surrounding area may be also included for clarification. The classified areas are shown on the 1:250,000 mylars or the prints of those that accompany each copy of this report, and classified areas for metals and nonmetallic minerals are outlined in greater detail on 15-minute topographic quadrangle maps in the GRA file.

As mentioned in the Introduction, the several small segments that make up WSA CA 010-075 have been assigned reverse alphabetical designations for easy referral, starting with Z for the northernmost and ending with R for the southernmost. The individual segments are shown on those accompanying 1:250,000 scale maps where the designations are needed.

In connection with nonmetallic mineral classification, it should be noted that in all instances areas mapped as alluvium are classified as having moderate favorability for sand and gravel, with moderate confidence, since alluvium is by definition sand and gravel. All areas mapped as principally limestone or dolomite have a similar classification since these rocks are usable for cement or lime production. All areas mapped as other rock, if they do not have specific reason for a different classification, are classified as having low favorability, with low confidence, for nonmetallic mineral potential, since any mineral material can at least be used in construction applications.

1. LOCATABLE RESOURCES

a. Metallic Minerals

WSA CA 010-075

M1-4C. This classification area includes segment Z of the WSA. It includes the known silver-base metal productive areas of the Montgomery Canyon district and the unnamed mining area two miles to the north that includes the Black Warrior mine (see Benton 15-minute topographic quadrangle). The geology in the WSA, both stratigraphy and structure, is the same as in the mined areas to the north and south, but no old diggings are known in it; this is the reason for the classification as highly favorable, but with only moderate confidence.

M2-2B. This classification area includes segment Y of the WSA. The rocks present in it are granitics, not the sediments that host the ores of the mined areas farther north in the vicinity of segment Z. The White Mountain Fault Zone, which may have played a part in the localization of the mineralization to the north, traverses the classification area. The east side of the area is the east side of the Fault Zone, and the west side is left open because presumably the Zone underlies the alluvium for an unknown distance out from the edge of bedrock. The classification of 2 is based on the presence of the fault zone, with low confidence.

M3-3D. This classification area includes segment X of the WSA. Its eastern boundary is drawn to include the marble unit of the Paleozoic metasedimentary bed shown by Crowder and Sheridan (1972); the north end is open because the unit continues beyond the WSA in this direction, and the west side is open because the unit presumably continues westward under the alluvium to the frontal fault of the range, the location of which is unknown. The Mountain View and Proctor mine is in this metasedimentary bed, and some of the mineralization associated with the mine is almost certainly within the WSA. Despite its name, it is unlikely that the mine actually has produced any ore (A. Baker III, personal communication), so it is treated as a prospect rather than a mine -- hence the classification of 3D.

M4-2B. This classification area includes segments W, V and part of U of the WSA. Its eastern boundary is the eastern fault contact of Permian, Triassic or Jurassic metasedimentary rocks that underlie the classification area. The northern end of the area is open as the metasedimentary rocks continue well beyond the WSA segments in this direction (Crowder and Sheridan, 1972). The west side is open, since the rocks presumably continue in this direction to the frontal fault.

The Copper Queen mine (actually a prospect) occurs in these rocks but is the only known metal occurrence, hence the low classification and low confidence level.

M5-1B. This classification area lies immediately south of M4-2B and extends a mile or two farther south but only its northern boundary is shown on the maps since this is the only part that has bearing on the WSA. The south half of segment U lies in the classification area. The rock in this classification area is Mount Barcroft granodiorite, with no structural deformation shown by Crowder and Sheridan (1972) in the vicinity of segment U of the WSA. Grandiorite in general is not a particularly favorable rock for mineralization, though it is mineralized in places as witness classification area M6-4D, following. The lack of structure is not encouraging. These are the reasons for the classification as very low favorability, and also for the low level of confidence.

M6-4D. This classification area includes segment T of the WSA. The rocks in it are the same granodiorite as in M5-1B, but here Crowder and Sheridan (1972) have mapped a fault traversing the granodiorite. The Sacramento mine is in the area, as is the Climax mine about 1,500 feet farther north; both have produced gold (Baker, 1966). Judging by the position of the Sacramento Mine as shown on the White Mtn. Peak topographic quadrangle, at least the lower adit of the Sacramento mine, and some of the veins to the north, are within segment T of the WSA, and both the main Sacramento workings and the Climax are within a very few hundred feet of it -- and may be in it. The presence of the mines and structural features are responsible for the highly favorable classification of the area and the high level of confidence.

M7-2B. This classification area includes the northern part of segment S and all of segment R of the WSA. Its northern boundary is drawn approximately along the southern edge of the contact metamorphism and copper-gold mineralization that lies between Paiute Creek and Coldwater Canyon; the other boundaries are not delineated since they have no bearing on the WSA. In this area there are no known mineral occurrences, but the rocks are similar to those that do contain mines and prospects to the north and south; hence the classification of low favorability with a low level of confidence.

M8-4D. This classification area includes the workings of the Southern Belle mine, which are considerably more extensive than those shown on the Bishop 15-minute topographic quadrangle. Bateman (1956, Plate 2) shows them extending nearly half a mile north of the Mono County boundary, within segment S of the WSA. The highly favorable classification and high level of confidence are based on the presence of the productive Southern Belle mine.

b. Uranium and Thorium

WSA CA 010-075

U1-2B. This land classification area covers the entire western border of the GRA and covers primarily Quaternary alluvial fan deposits. There is low favorability at a low confidence level for epigenetic sandstone-type uranium deposits in the area. A possible source for uranium could be the granitic rocks of the White Mountains. Uranium could be carried in ground water and precipitated in the permeable sands of the alluvium under favorable reducing conditions (e.g. in the presence of organic material).

A small aerial radiometric uranium anomaly (High Life Helicopters, 1980) just north of the section in T 3 S, R 33 E of the WSA and a uranium occurrence to the east of this section increase the favorability for a uranium deposit in this section of the WSA.

The area has low favorability at a low confidence level for thorium deposits which may occur as resistate mineral (monazite) concentrations in alluvial fan deposits. The Jurassic granites in the eastern part of the GRA are a possible source of thorium for these types of deposits. However, sufficient reworking of the alluvium to concentrate heavy minerals may not have occurred in alluvial fan environments.

U2-2B. This land classification, indicating low thorium and uranium favorability at a low confidence level, covers the entire eastern border of the GRA. The area is underlain by Cambrian sediments and metasediments, Jurassic granitic intrusives and Triassic-Jurassic metasediments and metavolcanics, and has low favorability for fracture-filling and contact-related uranium deposits which may have developed during emplacement of the Jurassic intrusions. Late-stage uranium bearing solutions which may have emanated from the cooling intrusives could have deposited uranium in faults and fractures along intrusive contacts or in the metasediments and metavolcanics. An aerial radiometric anomaly and a uranium occurrence of unknown nature are present in the northern part of the area, indicating that some uranium potential exists.

Uranium deposits may also occur in pegmatitc bodies which may be associated with the granitic intrusives.

The area also has low favorability for thorium deposits which may occur in pegmatites which may occur with the Jurassic intrusives.

c. Nonmetallic minerals

WSA CA 010-075

N1-4D. This classification area, at the south end of the GRA, includes part of segment R of the WSA. It is an area in which there are several productive pumice mines; the southernmost one may lie partly within segment R. The presence of the mines accounts for the high favorability and high confidence.

N2-2B. This classification covers all of the WSA except that part in N1-4D. The remainder of the WSA does not have occurrences of nonmetallic minerals. However, it should be noted that almost any mineral material can become a nonmetallic mineral resource, given an entrepreneur who can develop a market for it, such as in pigments or fillers; this is the reason for the low favorability and low confidence rating. It should be noted that the classification applies only to the segments of the WSAs. Much of the central part of the GRA outside the WSA segments is highly favorable for andalusite, pyrophyllite and rutile, while much of the southern part is highly favorable for barite.

2. LEASABLE RESOURCES

a. Oil and Gas

WSA CA 010-075

OG1-1D. There has been no serious oil and gas exploration, nor are there any recorded occurrences of oil and gas in this westernmost sector of the Basin and Range province where it meets the Sierra Nevadas. The eight WSA segments are underlain by Cambrian and pre-Cretaceous metamorphic rocks which rest on a main mass of the Sierran granitic batholith; all of these have no favorability for oil and gas resources.

b. Geothermal

WSA CA 010-075

G1-3B. This part of the White Mountain GRA lies along the deep-seated fault that formed the White Mountains on the east and the Chalfant and Owens Valleys on the west. It is along this type of fault that many Basin and Range geothermal systems persist where deep circulating waters rise to the surface or near-surface. The presence of Pleistocene volcanics (indicative of a heat source at depth) all along the western edge of the valley and numerous hot springs occurring over the same highly faulted area, provides a very favorable geologic environment and attendant geologic processes for geothermal resources. The greater portions of the WSA segments lie within this classification area.

G2-2B. The White Mountains, although broken somewhat by discontinuous faults, appears to be largely a monolithic body of granite with a veneer of Cambrian strata. The necessary structural dislocations are present that could be conduits for a geothermal system, but are not nearly as favorable as in G1.

c. Sodium and Potassium

S1-1D. This classification applies to the entire WSA. The geological environment is not favorable for the accumulation of resources of sodium and potassium.

d. Other Geological Resources

No other GEM resources have been identified in the WSA or the GRA.

3. SALEABLE RESOURCES

Saleable resources have been treated under the heading Nonmetallic Minerals.

V. RECOMMENDATIONS FOR FURTHER WORK

No further work is recommended in this WSA because it is made up of such small, widely-separated segments.

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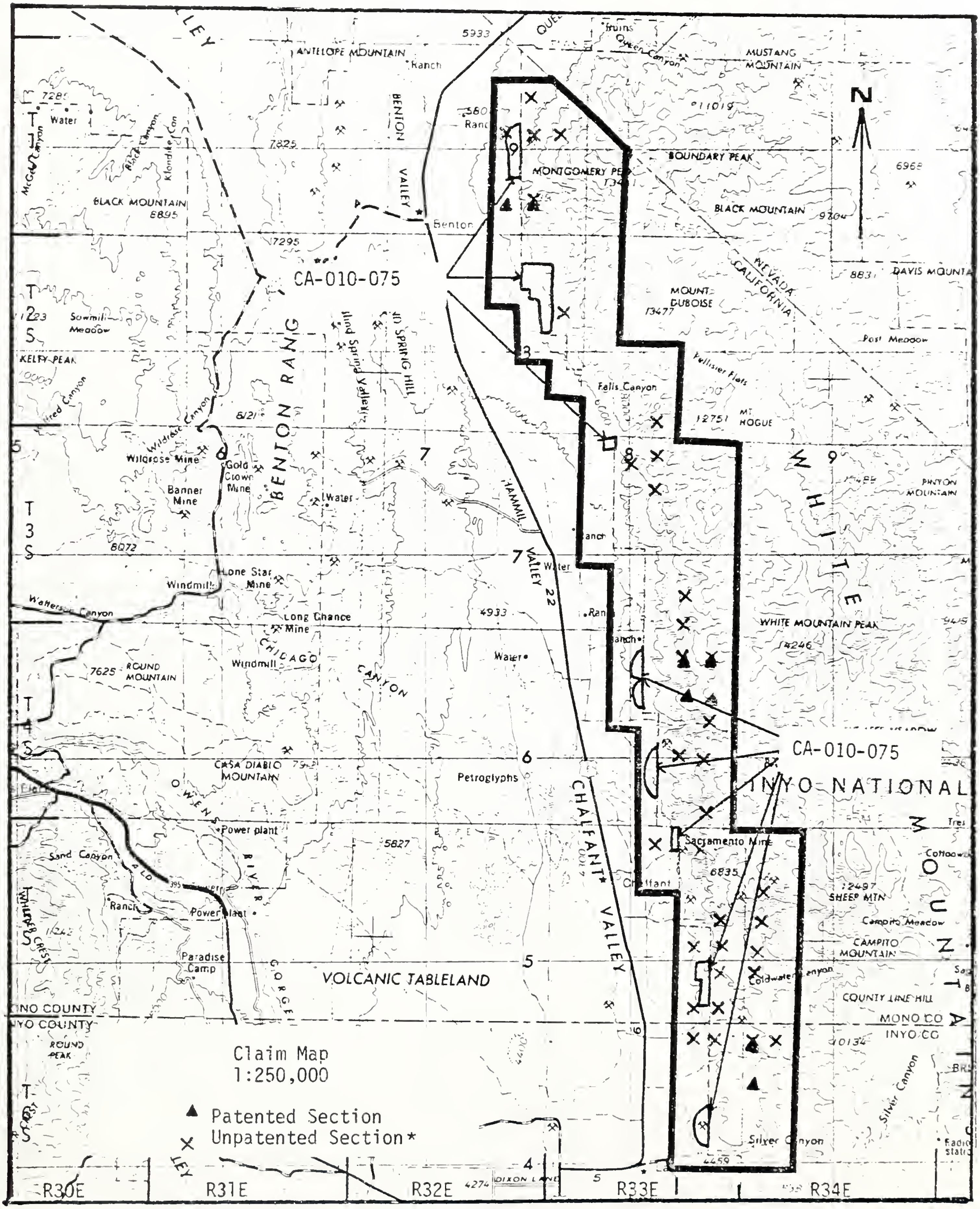
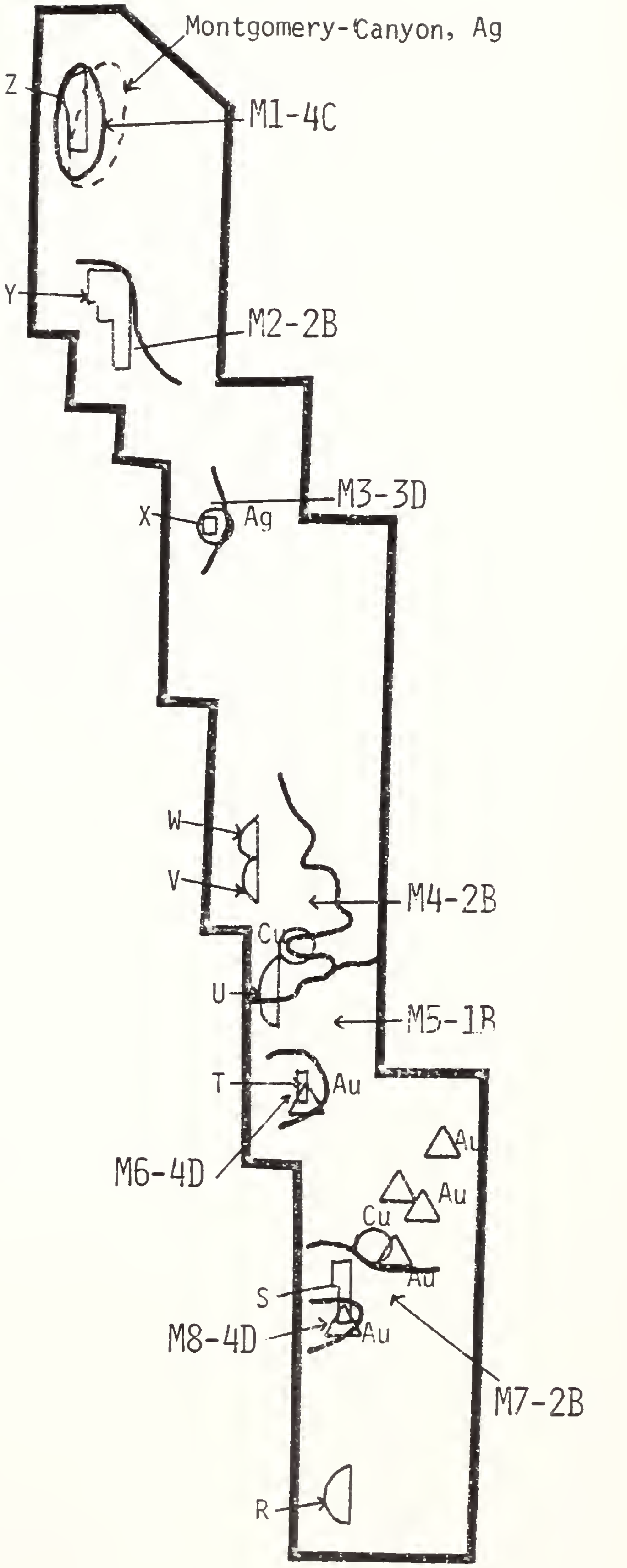


Claim Map
1:250,000

▲ Patented Section
X Unpatented Section*

*X denotes one or more claims per section



EXPLANATION

△ Mine, commodity

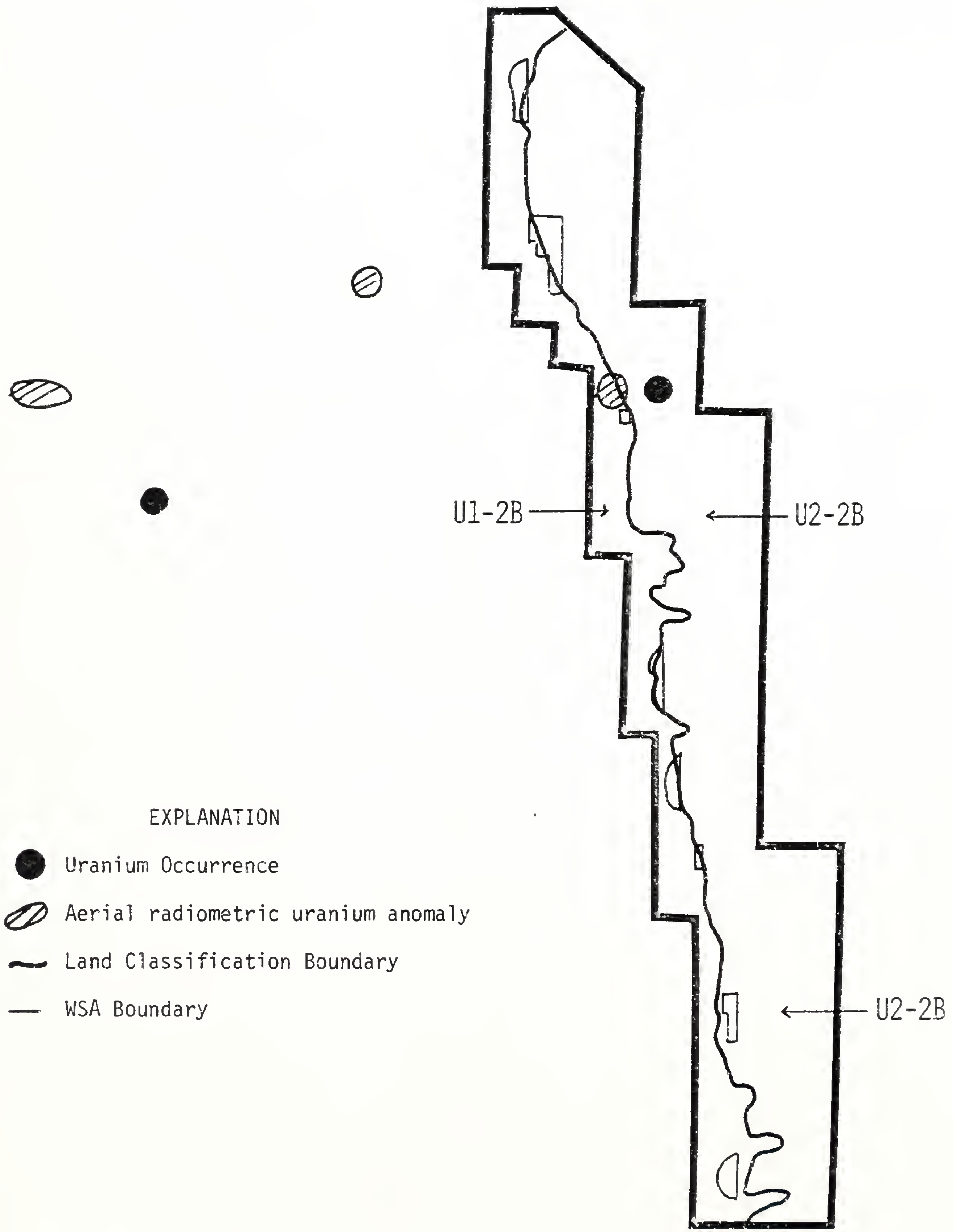
○ Occurrence, commodity

╱ Land Classification Boundary

— WSA Boundary

Land Classification - Mineral Occurrence Map/Metallics

White Mountain GRA CA-04
Scale 1:250,000



EXPLANATION

● Uranium Occurrence

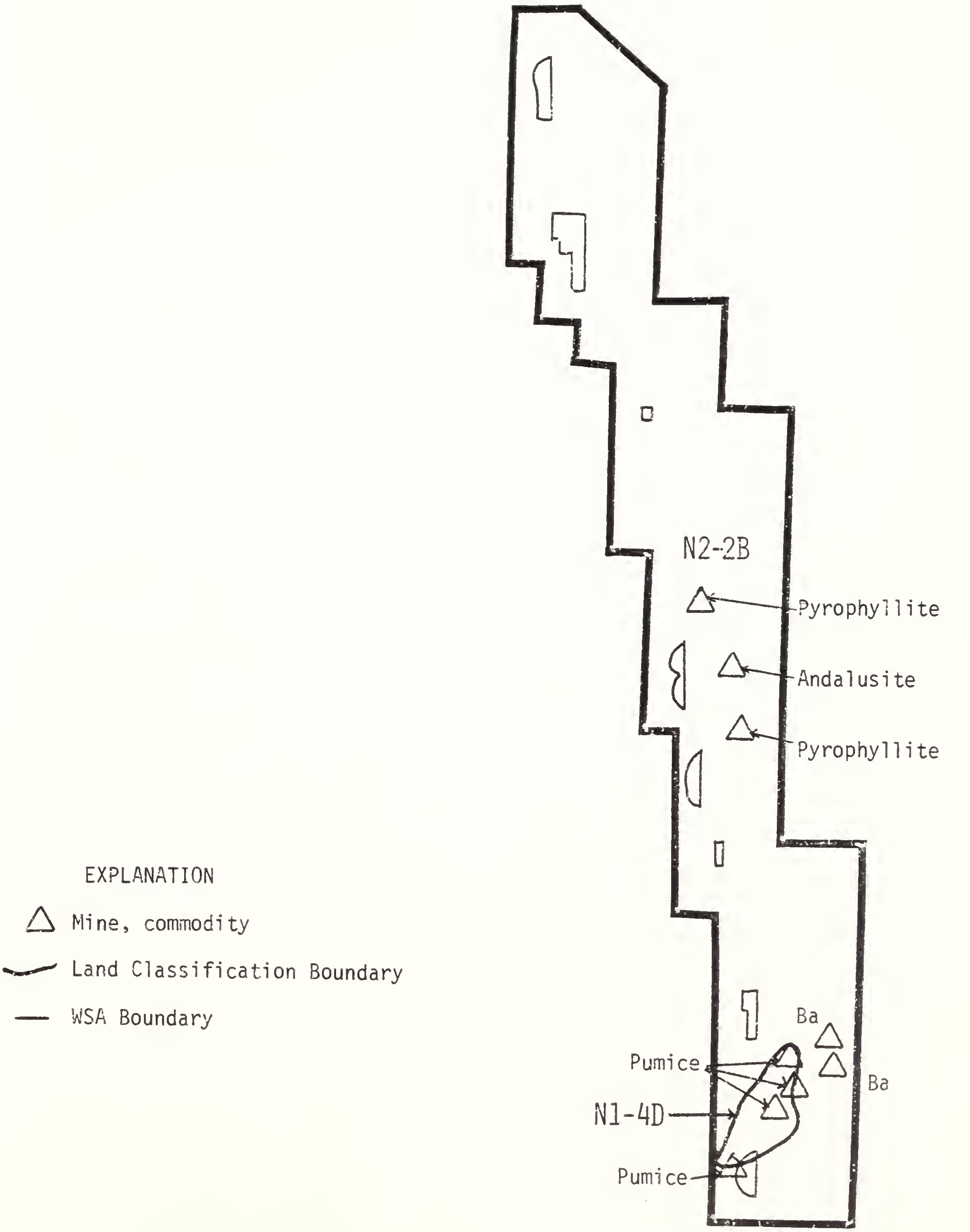
▨ Aerial radiometric uranium anomaly

Land Classification Boundary

— WSA Boundary

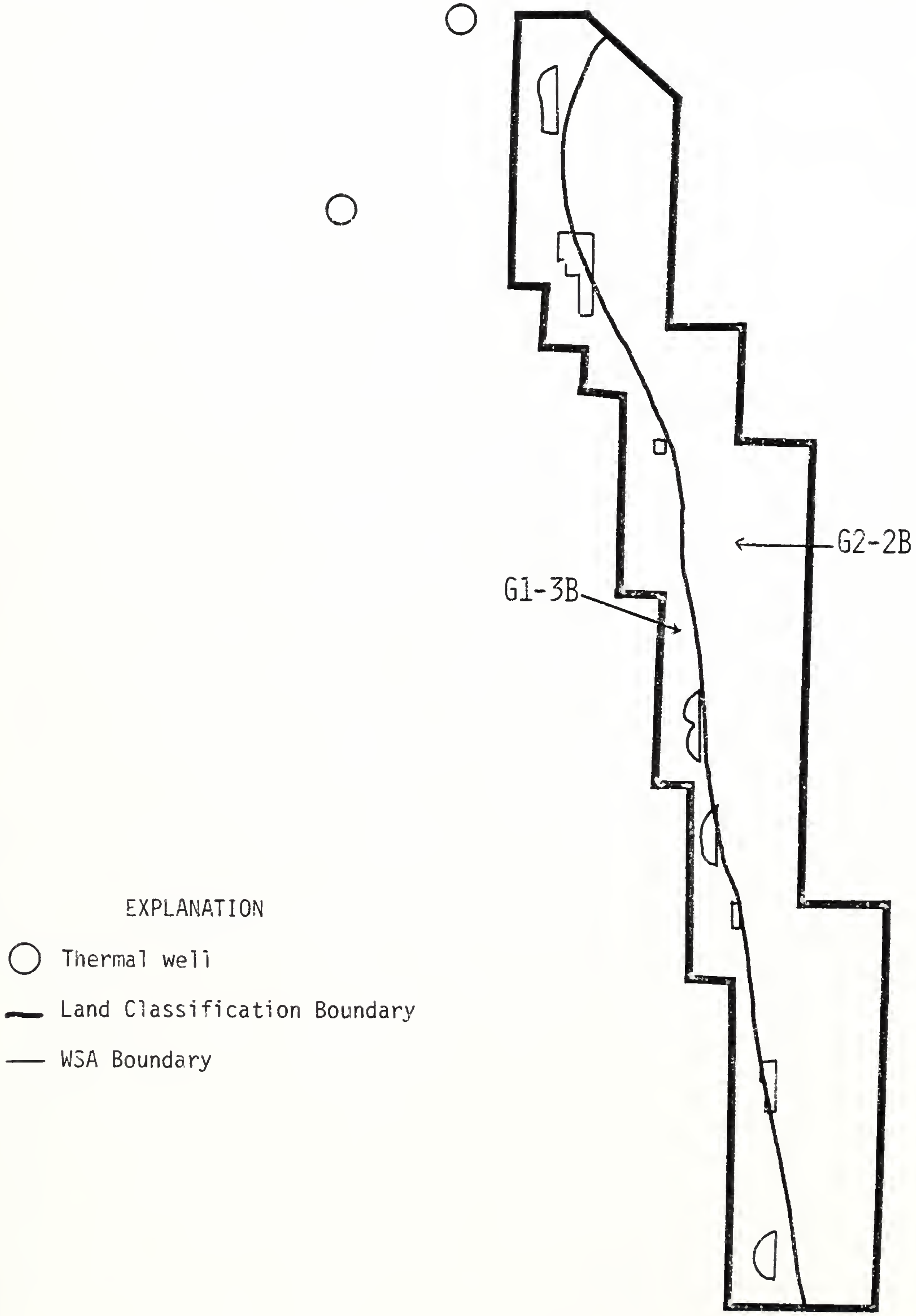
Land Classification - Mineral Occurrence Map/Uranium

White Mountain GRA CA-04
Scale 1:250,000



Land Classification - Mineral Occurrence Map/Nonmetallics

White Mountain GRA CA-04
Scale 1:250,000



Land Classification - Mineral Occurrence Map/Geothermal

White Mountain GRA CA-04
Scale 1:250,000

LEVEL OF CONFIDENCE SCHEME

A. THE AVAILABLE DATA ARE EITHER INSUFFICIENT AND/OR CANNOT BE CONSIDERED AS DIRECT EVIDENCE TO SUPPORT OR REFUTE THE POSSIBLE EXISTENCE OF MINERAL RESOURCES WITHIN THE RESPECTIVE AREA.

B. THE AVAILABLE DATA PROVIDE INDIRECT EVIDENCE TO SUPPORT OR REFUTE THE POSSIBLE EXISTENCE OF MINERAL RESOURCES.

C. THE AVAILABLE DATA PROVIDE DIRECT EVIDENCE, BUT ARE QUANTITATIVELY MINIMAL TO SUPPORT TO REFUTE THE POSSIBLE EXISTENCE OF MINERAL RESOURCES.

D. THE AVAILABLE DATA PROVIDE ABUNDANT DIRECT AND INDIRECT EVIDENCE TO SUPPORT OR REFUTE THE POSSIBLE EXISTENCE OF MINERAL RESOURCES.

CLASSIFICATION SCHEME

1. THE GEOLOGIC ENVIRONMENT AND THE INFERRED GEOLOGIC PROCESSES DO NOT INDICATE FAVORABILITY FOR ACCUMULATION OF MINERAL RESOURCES.

2. THE GEOLOGIC ENVIRONMENT AND THE INFERRED GEOLOGIC PROCESSES INDICATE LOW FAVORABILITY FOR ACCUMULATION OF MINERAL RESOURCES.

3. THE GEOLOGIC ENVIRONMENT, THE INFERRED GEOLOGIC PROCESSES, AND THE REPORTED MINERAL OCCURRENCES INDICATE MODERATE FAVORABILITY FOR ACCUMULATION OF MINERAL RESOURCES.

4. THE GEOLOGIC ENVIRONMENT, THE INFERRED GEOLOGIC PROCESSES, THE REPORTED MINERAL OCCURRENCES, AND THE KNOWN MINES OR DEPOSITS INDICATE HIGH FAVORABILITY FOR ACCUMULATION OF MINERAL RESOURCES.

MAJOR STRATIGRAPHIC AND TIME DIVISIONS IN USE BY THE U.S. GEOLOGICAL SURVEY

Erathem or Era	System or Period	Series or Epoch	Estimated ages of time boundaries in millions of years
Cenozoic	Quaternary	Holocene	
		Pleistocene	2-3 [1]
	Tertiary	Pliocene	12 [1]
		Miocene	26 [2]
		Oligocene	37-38
		Eocene	53-54
		Paleocene	65
Mesozoic	Cretaceous [4]	Upper (Late) Lower (Early)	136
	Jurassic	Upper (Late) Middle (Middle) Lower (Early)	190-195
	Triassic	Upper (Late) Middle (Middle) Lower (Early)	225
Paleozoic	Permian [4]	Upper (Late) Lower (Early)	280
	Carboniferous Systems Pennsylvanian [4]	Upper (Late) Middle (Middle) Lower (Early)	
	Mississippian [4]	Upper (Late) Lower (Early)	345
	Devonian	Upper (Late) Middle (Middle) Lower (Early)	395
	Silurian [4]	Upper (Late) Middle (Middle) Lower (Early)	430-440
	Ordovician [4]	Upper (Late) Middle (Middle) Lower (Early)	500
	Cambrian [4]	Upper (Late) Middle (Middle) Lower (Early)	570
Precambrian [4]		Informal subdivisions such as upper, middle, and lower, or upper and lower, or younger and older may be used locally.	3,600 + [3]

[1] Holmes, Arthur, 1965, Principles of physical geology: 2d ed., New York, Ronald Press, p. 360-361, for the Pleistocene and Pliocene, and Obradovich, J. D., 1965, Age of marine Pleistocene of California: Am. Assoc. Petroleum Geologists, v. 49, no. 7, p. 1087, for the Pleistocene of southern California.

[2] Geological Society of London, 1964, The Phanerozoic time-scale; a symposium: Geol. Soc. London, Quart. Jour., v. 120, supp., p. 260-262, for the Miocene through the Cambrian.

[3] Stern, T. W., written commun., 1968, for the Precambrian.

[4] Includes provincial series accepted for use in U.S. Geological Survey reports.

Terms designating time are in parentheses. Informal time terms early, middle, and late may be used for the eras, and for periods where there is no formal subdivision into Early, Middle, and Late, and for epochs. Informal rock terms lower, middle, and upper may be used where there is no formal subdivision of a system or of a series.

GEOLOGIC NAMES COMMITTEE, 1970