MINES AND MINERALS OF THE GREAT AMERICAN RIFT

COLORADO NEW MEXICO

Richard Walker Holmes
Marrianna B. Kennedy

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DEDICATION

We dedicate this book to the concept that all possible steps should be taken to preserve our mineral heritage, whether in physical form as irreplaceable specimens, as information of their formation, or background of their occurrence. Our part of saving this heritage has been enjoyable and our wish is to share past experiences and information.

Space will not permit recognition of all the dedicated workers who have advanced our understanding of the Great American Rift. The scientific literature carries voluminous listings. To say our work drew heavily from all is a gross understatement. Where else is the information available? If this work can be considered a tribute to them, we would be pleased.

We assume no credit for their work, only for pertinent omissions and possible misinterpretations. We hope these are few.

This work is also dedicated to the early miners and prospectors whose dreams and visions, not to mention their determination and perseverance, hammered out of the frontier wilderness a mineral industry; and to past, present and future mineral collectors, whether in vaulted halls or humble miner's shacks. Their appreciation of symmetrical beauty in naturally formed objects binds them together in a single brotherhood. These we salute.

WARNING

Most mineral properties are in private ownership and permission to enter must be obtained to prevent trespass. Old mine workings are dangerous and entering underground openings without an authorized person can end in disaster.

My wholehearted appreciation goes to my wife, Wanda, who by her patience and understanding over many years, made my mineral collecting possible and by ably handling the grim logistics of everyday living made time available for writing and research.

R.W.H.

PREFACE

The purpose of this book is to preserve information about the mines and minerals of the Great American Rift in New Mexico and Colorado. Great American Rift is the name we use for a major continental rift that extends from Mexico along the Rocky Mountain Front to possibly the North Slope of Alaska. In New Mexico and Colorado, this rift zone is between the stable plates, or large blocks of the earth's crust, of the Great Plains and the Colorado Plateau. This rift zone contains the mines that have produced most of the mineral wealth for which these states are noted.

Information about many of the mines and their minerals is becoming scattered or lost to the mineral collector and hobbyist. Many sources are no longer available.

We hope we have recovered and preserved some of this information for the future. We also hope to introduce to the reader the concept of a great split or rift in the earth's crust that was responsible, directly or indirectly, for the many mineral deposits it exposed.

Richard Walker Holmes
Marrianna B. Kennedy

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Research Assistant: Gary D. Streetman

Director of Photography: Jack R. Morrison

Contributing Photographers: Tom E. Carpenter
Wanda H. Holmes
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All photographs except those listed by initials of the contributing photographers are the work of Jack R. Morrison.

All specimens photographed were from the collections of the authors, with the exception of the rhodochrosites of the Sweet Home Mine, Alma, Colorado, which were loaned for photography by Norman L. Bennett.

CONTENTS

CHAPTER 1
THE GREAT AMERICAN RIFT

GENERAL

A rift is a large fissure (split) in the earth's crust that can be traced for some distance along the surface. A fault is a similar fissure, usually smaller, and it does not have certain rift characteristics. Rifting is a tectonic event because it changes the crust of the earth along the rift for a long period of geologic time. Movement of magma under a rift is caused by the release of crustal pressure.

Some of the criteria for determining if an active rift exists are seismic activity and abnormal heat flow. These conditions may indicate emplacement at shallow depth of igneous rock masses or pending volcanic activity. Thermal springs frequently occur along rifts. Visible surface evidence is the occurrence of rift valleys that trace the rift as a depression, usually of steep profile, graben valleys and rift valley lakes. Indications of former volcanic activity and the formation of calderas, large collapsed structures due to removal of material from the underlying magma chamber, are significant of rift activity. Large varieties and quantities of igneous rocks are usually found along rift zones.

Continental rifts are large enough to extend the length or width of a continent. The East African rift, in Ethiopia, is 600 miles wide, but the innermost or main rift is smaller. It is usually the most recently active part of a rift.

Rock material from the walls of a rift fall in to form the valley floor. In desert areas where there is insufficient alluvium to fill the rift valley, a deep gorge may develop between the steep and narrow walls. This is another topographic feature that defines a rift. Where there is more rainfall and more runoff from the surrounding area the rift will be filled with alluvium and it may be more difficult to identify. Rift valley lakes are a distinctive feature of rifts and often they are unusually deep. Lake Baykal, in the Baykal Rift of central Asia, is the world's deepest lake (5315 feet); Lake Tanganyika (over 5000 feet) and Lake Nyasa, both formed in the Great Rift Valley of East Africa, rank with the world's deepest.

The crust of the earth is separated from the mantle, at a depth of about 21.0 miles on land and about 6.0 miles under the oceans, by the Mohorovicic Discontinuity. This discontinuity marks a radical change in composition of the rocks from a more solid state to a more plastic state. Under the deeper oceans the crust is composed of basalt and rifts occur under the oceans as well as on the continents. Basalt, a dark to black heavy igneous rock, is composed principally of iron and magnesium (ferromagnesian) minerals. On continents, the crust is made of less dense rocks rich in silica (silicic) such as granitic rocks and transported rocks. Transported rocks also occur offshore near the continents.

If longer and wider blocks of the earth's crust slip down into the rift, more or less as a unit, a graben valley is formed. A large graben valley, such as the Rhine Graben of Europe, may also be a rift system. Walls of a graben are formed by near-vertical or normal faults. These faults are also called graben faults and often remain as scarps along the graben.

Areas above the fault scarps are called horst blocks. They continue to rise (or horst) as the graben block continues to sink into the less dense magma along and under the rift zone. Auxiliary faults along the rift may be shallow or deep-seated; however the graben faults extend to a depth where rock is becoming plastic and can flow. (Fig. 1-1).

Plastic magma moving toward the rift, where pressure has been lessened by the original break or rift, tends to make the area, in general, rise and this stretching of the crust makes it thinner. Many rift-related events, therefore, take place along the rift but at a distance from it. The phonolite plugs and other intrusive forms along the East African Rift occur as far as 75 miles from the rift, yet they are rift related.

Phonolite is a name used for igneous rocks of the phonolite-nepheline syenite group. Soda orthoclase is the principal mineral and carbonic acid is present in many magmas. It is thought to be formed from assimilated carbonate rocks. The name was suggested from the characteristic sound it makes when struck with a steel object.

Along a rift, the general overall effect is for the area, especially the horst blocks, to continue to rise as the graben continues to sink deeper into the rift. If graben filling keeps pace with sinking, the structure may be difficult to determine.

It could be expected that the activity along a continental rift although it extends over varying geologic time, would not be uniform. Batholiths, large

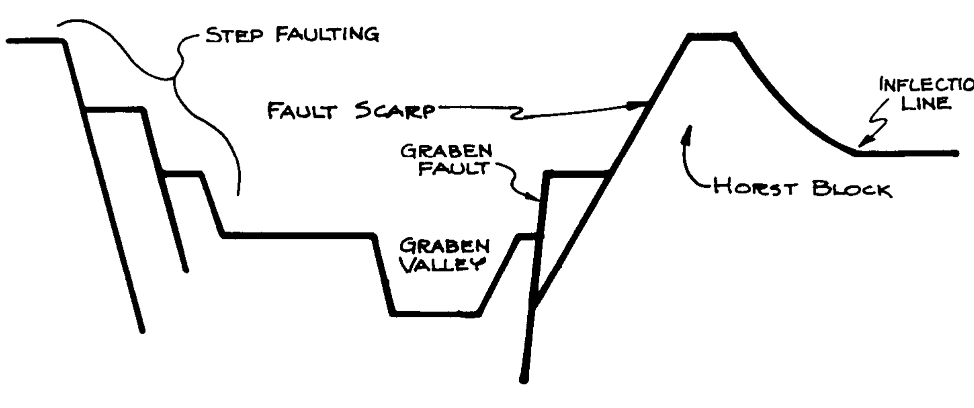

Fig. 1-1. Horst and graben faults in cross section.

masses of generally silicic material lighter and more fluid than the larger mass of ferromagnesian material below, rise into the crust. The top or roof of a batholith tends to stope its way upward by cracking the overlying rock and forcing it into the magma. This rock, called xenoliths if smaller and roof pendants if larger masses, sinks to where the density of the magma will support it and generally it is assimilated into the melt, thereby changing the composition of its host. This process is called magmatic stoping. As conditions vary, the roof is not at the same elevation over the batholith. Some parts of the magma may be more fluid and rise faster to form cupolas that are rounded, vault-like structures.

Frequently, cupolas spawn smaller forms of igneous intrusives such as stocks, plugs, sills, dikes, laccoliths, pipes, chimneys, and less common forms. (Fig. 1-2)

If magma reaches the surface, volcanic activity produces ash, tuff, agglomerate, breccia, or other forms of pyroclastic materials. Lava flows may occur. After prolonged activity, which may extend over millions of years, large

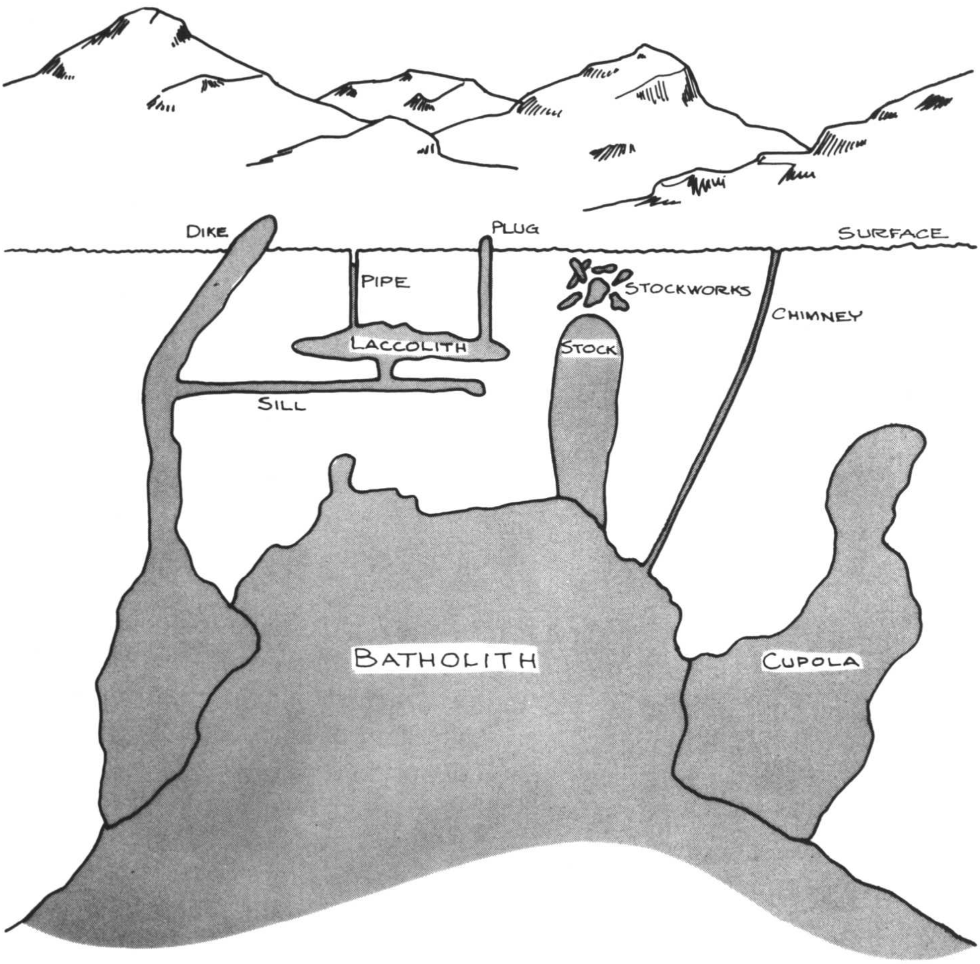

Fig. 1-2. Generalized section of igneous intrusions.

relatively circular areas around the vent collapse to form a caldera. Should one side not fall all the way in and a hinge develop, the resulting structure would be called a pocket-book or hinged caldera. The Silverton caldera in Colorado is such a structure.

Rifts occur all over the world, on land and under the oceans. They are most numerous in the oceans and some of the largest rifts are found in the Mid-Ocean Ridge of the Indian Ocean and the Mid-Atlantic Ridge of the Atlantic Ocean. The ridges seem to form a line of expelled magma connecting the cross-cutting rifts. They may be special expressions of rifts themselves. The Dead Sea, Red Sea, and Gulf of Aden all occupy large rift valleys.

The largest continental rift is the Great Rift Valley of East Africa. It extends from the Red Sea Rift along the east side of Africa to South Africa. In Kenya, Uganda, Burundi, and Tanzania it forms two parts around Lake Victoria, which may occupy a depression that is rift-related. The more concentrated rift system, composed of parallel fault swarms, goes west around the lake and the largest, or at least widest, part goes around the east side. It is called the Eastern Rift System. Kilimanjaro, 19,340 feet high and the highest point in Africa, is a volcano in the Eastern Rift System. Lake Tanganyika is in the west part of the rift. The Great Dike of Southern Rhodesia extends through the Limpopo Belt and Bushveld Complex, two highly mineralized areas of the rift, to the vicinity of Kimberly, in South Africa. It is almost 1000 miles long and considered to be rift-related.

Baykal Rift in Central Asia and the Rhine Valley Graben in Europe are other well known continental rifts. Continental rifts are part of a global system of crustal movement that involves the ocean spreading of continents. This is the science of plate tectonics.

The following is our understanding of the formation of continental rifts.

Tensional breaks occur in the earth's crust because it is weak in some places and not strong enough to sustain itself in large segments. It breaks into large plates and continental rifts occur where these plates meet. There is a tendency for rifts to occur where older zones of weakness existed. Rifts are said to be cross-cutting structures; however, they might be considered as joining together a series of such older and smaller zones of weakness like the break that occurs in a piece of flagstone when a series of hammer blows are made in a straight line to break it.

All major metallic ore deposits are near and related to large silicic masses of intrusive rocks. Smaller centers of mineralization were formed in smaller centers of igneous intrusives. The old prospector's maxim that porphyry, a spotted rock by his terminology, was the mother of gold, actually helped him to find the Bonanzas (big, rich mineral deposits) of the West.

Rift zones have deep-seated faults through which igneous rocks can rise into the crust. These intrusives formed channelways through which the hydrothermal solutions rose to where they were deposited as ores.

The more common forms of igenous intrusives found along rift zones are: (Fig. 1–1)

Older batholiths:	Often exposed by erosion or mining. Often intruded by younger igneous rocks.
Stocks:	Column-like, generally rounded, large masses.
Pipes:	Smaller than stocks but also column-like and rounded or circular.
Chimneys:	Smaller, in general, than a pipe; however, pipes a few feet in diameter are known.
Plugs or stubs:	Usually filling an old crater, also a rounded mass.
Dikes:	Near vertical to vertical sheets formed between fault walls.
Sills:	Near horizontal to horizontal sheets usually formed between sedimentary bedding planes or other zones of weakness.
Laccoliths:	Mushroom-shaped masses usually with a flat bottom or floor and usually with a dike, pipe or chimney as a feeder conduit; found in sedimentary rocks where resistance of overlying beds forced the magma from the feeder conduit to spread laterally.
Lopoliths and chonoliths:	Irregular forms, not symmetrical in any respect.

These intrusive forms all have one thing in common. They follow zones of weakness and form their own zones of weakness. By cracking up the enclosing rocks they form breccia (crushed rock) zones, and may themselves be brecciated, to form stockworks, by fresh surges of intrusives from below. Brecciated stocks, pipes, and chimneys are common forms.

Hydrothermal (from water + heat) solutions are formed in the magma at great depth. Pressure and heat are high as it is a confined system within the magma chamber. Superheated ground water with metallic content may join the system as it moves into the crust. Metallic ions of gold, silver, manganese, copper, lead, zinc, iron, molybdenum, tin, tungsten, uranium, and less common ones are deposited in the crust as primary sulfides, oxides, carbonates, and less common forms. Breccias and other zones of weakness are the hosts for these minerals, which form the ores of commerce and minerals for collectors.

The part that rifting plays in exposing mineral deposits is extremely important. Erosion and changes in drainage patterns have exposed many of the metalliferous deposits of New Mexico and Colorado.

In the Leadville district of Colorado (Fig. 1–3), an area about four miles long was step-faulted down into the rift so as to expose bonanza mineralization at different elevations. Step-faulting into the rift is also common in the East African Rift System. We feel that rifting in New Mexico and Colorado is responsible for most of the mineral wealth represented by the metal deposits of these two states. This rifting reoccurred along zones of weakness that existed for a long span of geologic time.

Van Alstine found in his studies of continental rifting that fluorine, as

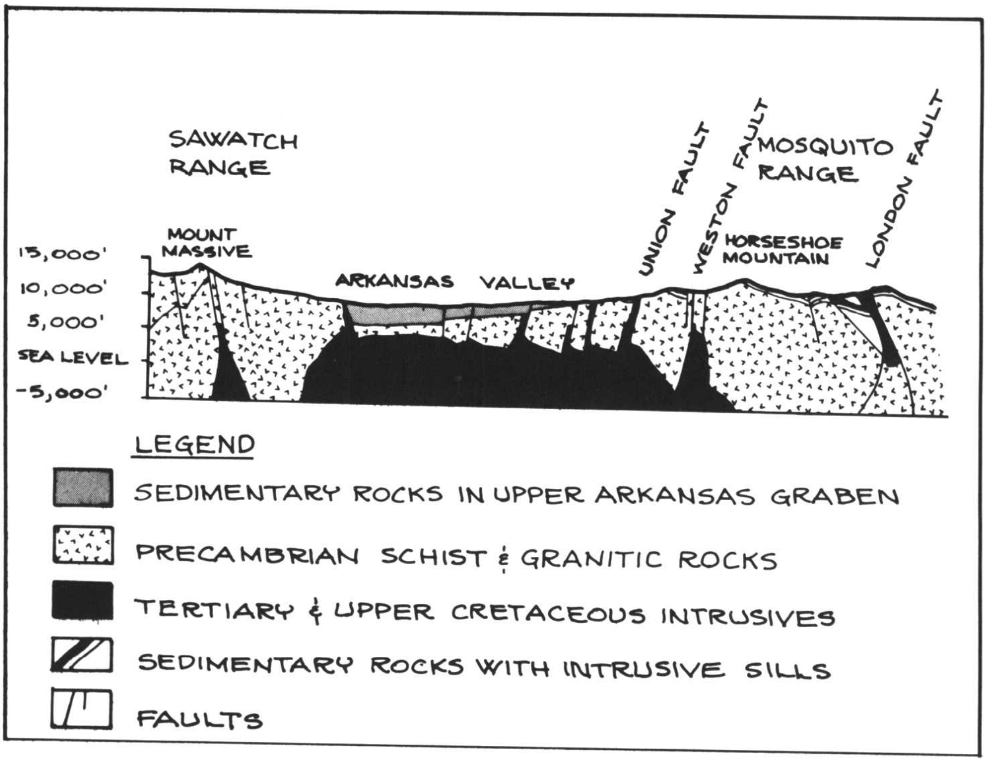

Fig. 1–3. East-west cross section of Upper Arkansas Valley near Leadville, Lake County, Colorado. Adapted from U.S.G.S., P.P. 726–c, 1972.

fluorspar, the impure fluorite of commerce, occurs consistently along continental rifts in North America and Africa. Thermal springs in the rift zones contain fluorine and some are depositing fluorspar. The world's largest concentration of fluorspar occurs in the Bushveld Complex in the Eastern African Rift System, in South Africa.

CARBONATITES: A SPECIAL RIFT-RELATED IGNEOUS ROCK FORM

A carbonatite is a rock derived from deep magmatic sources; it is rich in carbonate material. Carbonatites occur in the same forms as other igneous rocks and may form as large volcanoes or as small dikes and associated veinlets. Although they are not exclusively rift-related, they are most numerous and most often found along rifts. The Eastern Rift System of Africa has by far the largest number of them. Their composition is not constant.

Kimberlite is primarily a matrix of serpentine and carbonate material and the diamond pipes near Pretoria have carbonatite dikes in them. Kimberlite is considered a form of carbonatite.

Phonolite, nepheline syenites, and alkalic rocks, such as Bostonite porphyry, a common rock of the Colorado Front Range mineral districts, are forms of carbonatites.

It is thought that carbonatites are formed by recrystallization of modified or original magma; from hydrothermal solutions, or by remobilized carbonate rocks or material. They are considered to be of secondary or remelted crustal material.

Fluorite occurs with many of the African carbonatites, such as with those of the Bushveld Complex. It is being mined commercially as fluorspar from carbonatite sources. Carbonatite ash beds are being considered for commercial fluorspar mining.

At Phalabora, Transvaal, Africa, a carbonatite contains a major copper deposit. It is radioactive from baddeleyite and uranoan thorianite and two stages of fracturing introduced chalcopyrite and other copper minerals.

Carbonatites have a distinctive suite of minerals that includes thorium and the rare-earth minerals. Other than fluorite—barium, titanium, strontium, zirconium, iron, and copper are often present in varying amounts.

In a caldera near Pretoria, South Africa, in the rift zone, a salt pan contains a soda lake with the salts introduced by volcanic vapors. It is associated with a carbonatite body and dolomite-calcite matrix cements material ejected from a former vent. A layer of gaylussite occurs in the bottom of the lake below a layer of mud and chalcedonic concretions. Similar carbonatite-related deposits occur at Lake Magodi, where nahcolite, natural baking soda, occurs, and at other rift-related lakes and thermal springs along the rift system of Eastern Africa.

Heinrich presents an interesting speculation that the Eocene carbonate-rich evaporite deposits of the Green River Formation of northwestern Colorado and adjacent Utah and Wyoming may have been formed as a result of volcanic activity. The volcanic rocks of the Leucite Hills (rift-related carbonatite) were erupted through the Green River beds. Ash beds are found in this shale and evaporite formation. Trona, nahcolite, and shortite are the principal carbonate minerals of these shale beds that are also oil bearing. At least 21 other carbonate minerals have been identified.

It has been estimated, by C. Mains, that 29 billion tons of nahcolite and 10 billion tons of dawsonite are in the evaporite beds of the Piceance Basin of Colorado. This area is only a small part of the extensive oil shale beds. Such a concentration of carbonate material is unknown elsewhere. The minerals are considered primary in this inland lake deposit.

In the Great American Rift in New Mexico, one- to two-foot dikes of carbonatite cut an oval explosion breccia body, about a third of a mile long, in Precambrian (Fig. 1-4) rocks. This occurrence is in the Lemitar Mountains at Mount Largo, about 22 miles north of Albuquerque. One such dike was found to contain fine-grained calcite, dolomite, magnetite, apatite, phlogopite, and pyrite.

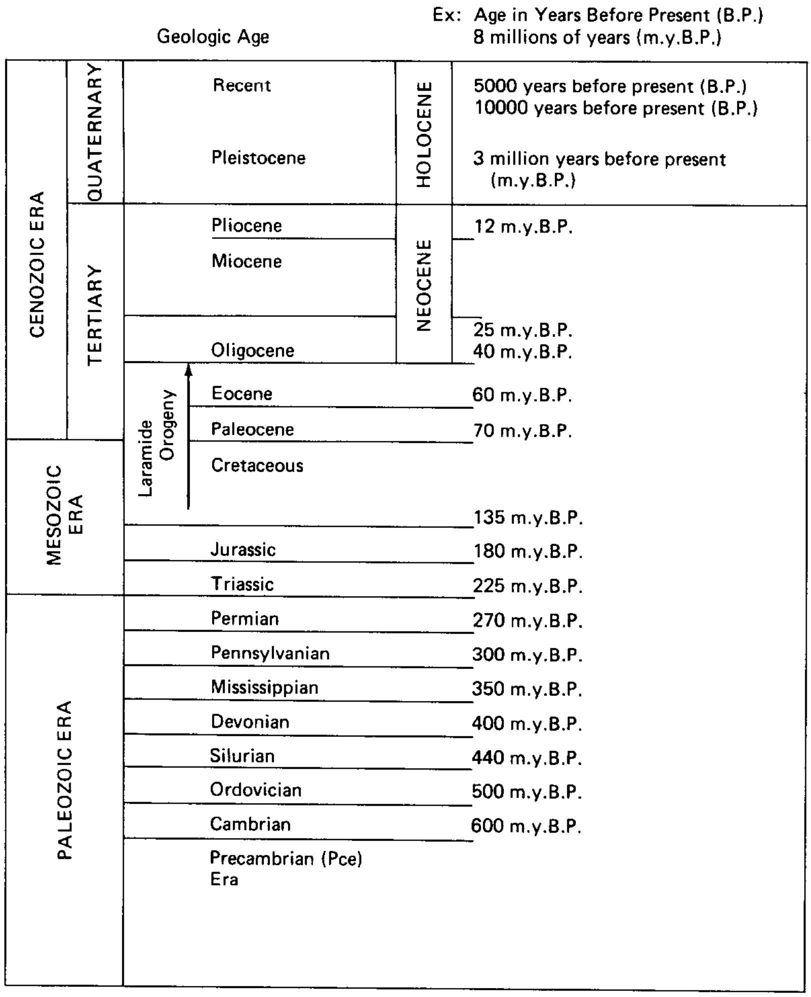

Fig. 1-4. Time chart. Adapted from Newman, 1976 and Hawley, 1978.

In Colorado, carbonatite occurs in the Powerderhorn district, at Iron Hill. Thorium and rare-earth minerals are present and a deposit of ilmenite has been prospected.

In the Wet Mountains, near the Pleasant Valley Graben, a rift-related structure, carbonatites occur in Precambrian (Pce) rocks and as three centers of alkalic intrusives known as the Democrat Creek stock, Gem Park stock, and McClure-Iron Mountain Complex. The area has been prospected extensively for thorium.

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G-12, H-15, J-2, J-3, J-27, J-29, J-33, J-47, J-52, 0-14 (Reiter), S-70, S-95, S-112, S-132, S-140, National Geographic Society Maps—Pacific Ocean Floor, Atlantic Ocean Floor, and Indian Ocean Floor.

DETAILS OF THE GREAT AMERICAN RIFT

The Rocky Mountain Trenchtintina, of the Desert Bolson zone north of Mexico City, is the lower part of a continental rift system that extends north up the Rio Grande of New Mexico and southern Colorado, continues north through the central part of Colorado into Wyoming, extends through Idaho and Montana into Canada, and goes on to the North Slope of Alaska. We call this rift system the Great American Rift. Our primary interest and mineral collecting experience has been in New Mexico and Colorado and this book is primarily concerned with the rift in those states.

The Western Great Plains and the Colorado Plateau are two relatively stable blocks or plates and the area between them is considered the rift zone, an area in which great batholiths formed along with Pce faults that still exist. The rift zone was active in Pce time; in Pennsylvanian time; extremely active in the Laramide orogeny, and again in Neocene to Recent time. The Pce batholiths were repeatedly invaded by younger intrusives. It was in Neocene to Recent time that the latest rifting occurred.

Lower Rio Grande

At El Paso, Texas, the Walker or Texas lineament crosses the Lower Rio Grande part of the rift which is about 175 miles wide along this lineament. A lineament marks a change in geologic formations or a series of physical units aligned in one direction. The Walker lineament marks the south end of the Colorado Plateau, west of the Rio Grande, and continues on to the West Coast. (Figs. 1-5 and 1-6).

Three large basins, the Tularosa, Mesilla, and Mimbres, in this area are filled with deep deposits of sediments, all rift-related. North along the Rio Grande are the Jordana, Palomas, and San Marcial Basins, also rift-related deep basins filled with similar sediments.

East of Las Cruces the Organ Mountains, remnants of an old batholith, and northward the Caballo, Fra Cristobal, Sierra de los Uvas and Potrillo Mountains form a more or less continuous fault scarp and discontinuous horst blocks along the east side of the Rio Grande.

On the west side of the Rio Grande Valley, on the edge of the Colorado Plateau, the Central mining district is centered around Silver City and the Santa Rita Open Pit Copper Mine. It has been the most productive mineralized area in New Mexico.

Between Las Cruces and the Central mining district is the Good Sight-Cedar Hills volcanic-tectonic depresion (39 to 33 m.y.B.P.-million years Before Present) which has over 2000 feet of rift-related fill material. Rifting in this area was evident by 26 m.y.B.P.

Two calderas occur in the Organ Mountains, the Dona Ana (37 to 33 m.y.B.P.) and the Organ (32 m.y.B.P.). About 9000 feet of ash-flow tuff has collapsed into the Organ batholith magma chamber, in the Organ caldera.