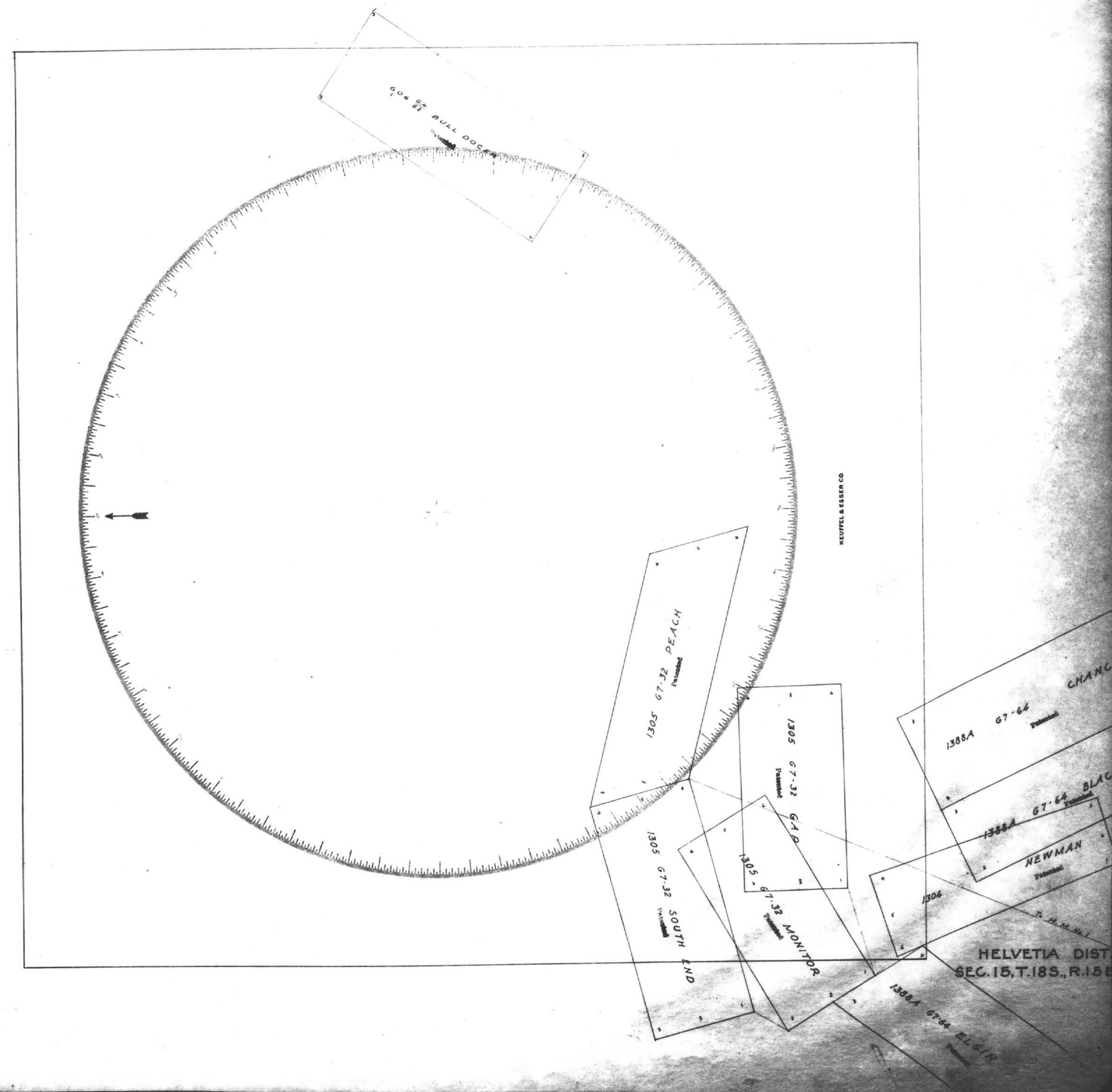
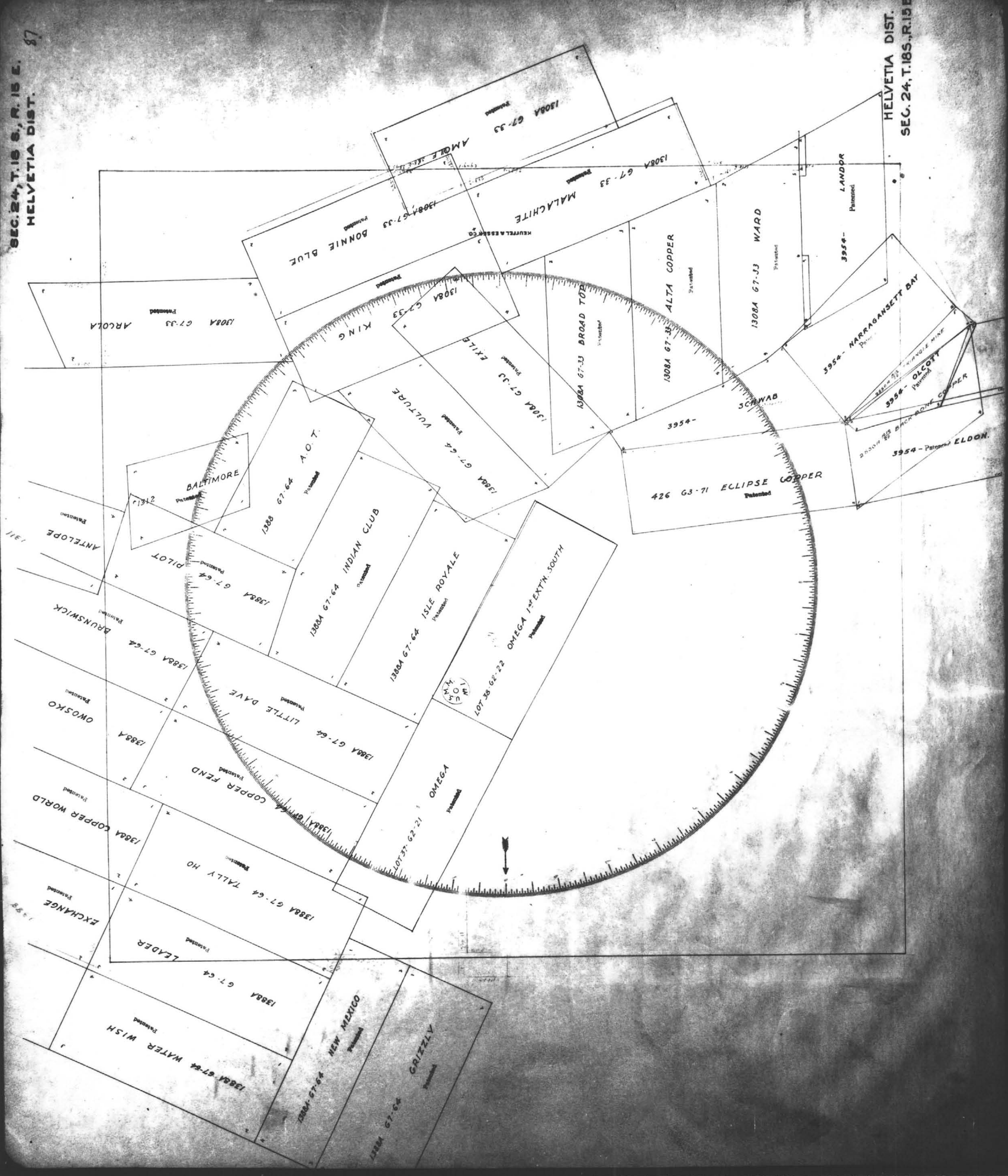
CONTACT INFORMATION
Mining Records Curator
Arizona Geological Survey
3550 N. Central Ave, 2nd floor
Phoenix, AZ, 85012
602-771-1601
http://www.azgs.az.gov
inquiries@azgs.az.gov

SEC. 15, T. 18 S., R. 15 E.
HELVETIA DIST.

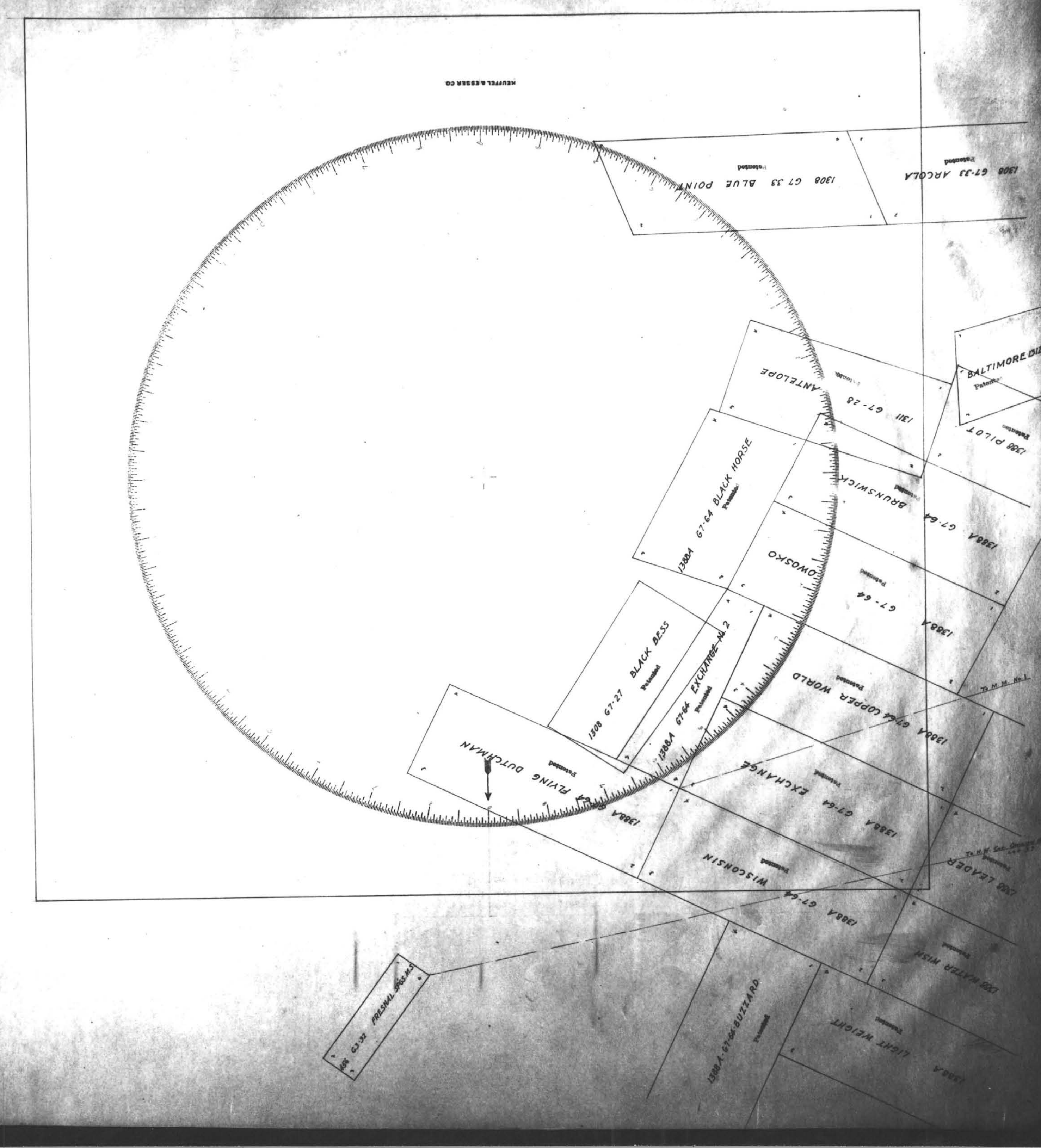
84



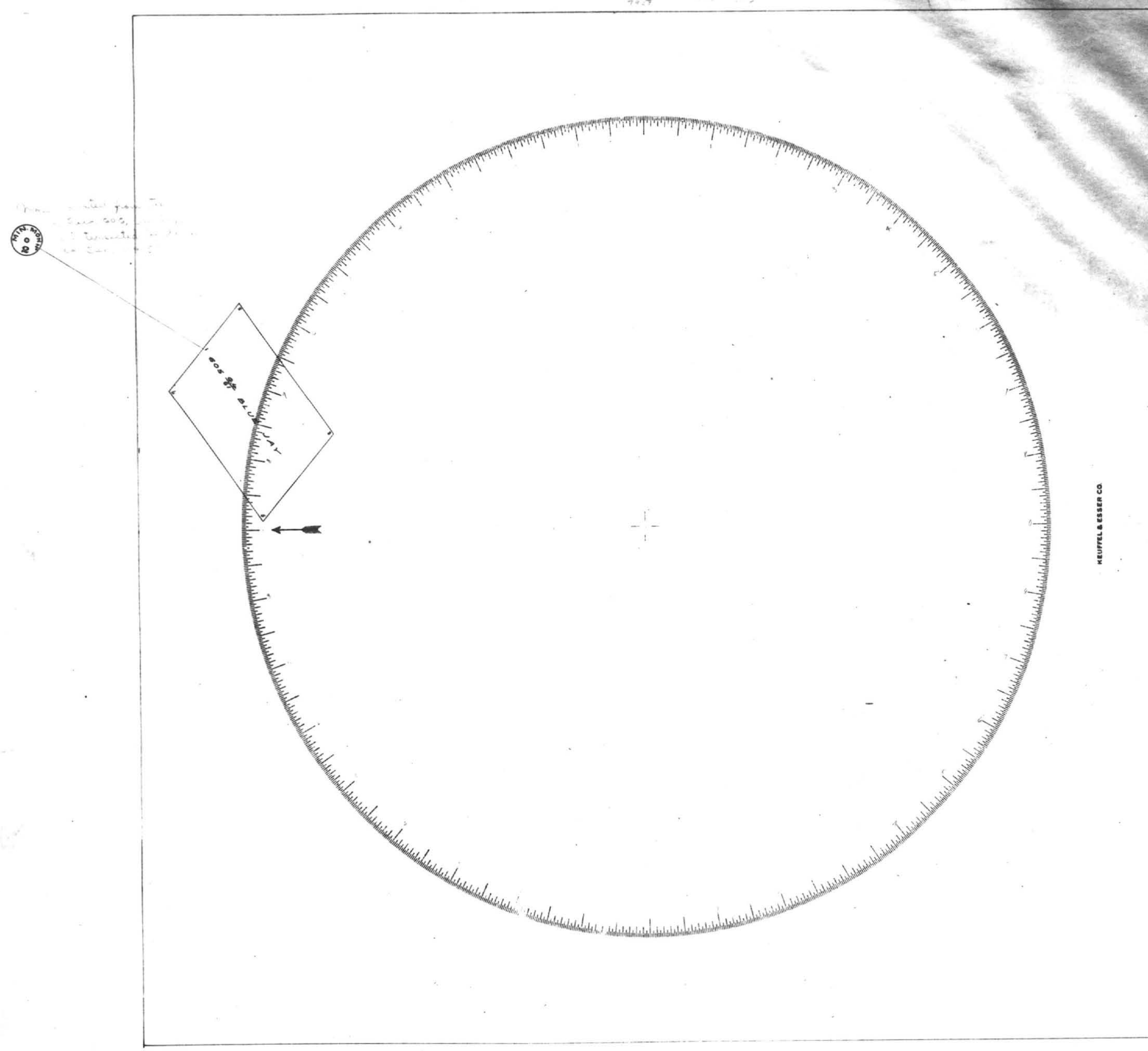

SEC. 24, T. 18 S., R. 15 E.
HELVETIA DIST.
87
HELVETIA DIST.
SEC. 24, T.18S., R.15E
1308A G7-33 AMOLE Patented
1308A G7-33 MALACHITE Patented
1308A G7-33 BONNIE BLUE Patented
KEUFFEL & ESSER CO.
1308A G7-33 ARCOLA Patented
1308A G7-33 KING Patented
1308A G7-33 EXILE Patented
1308A G7-33 BROAD TOP Patented
1308A G7-33 ALTA COPPER Patented
1308A G7-33 WARD Patented
3954- LANDOR Patented
3954- NARRAGANSETT BAY
3954- OLCOTT Patented
3954- SCHWAB
3954- Patented ELDON.
426 G3-71 ECLIPSE COPPER Patented
1388A G7-64 VULTURE Patented
1388 G7-64 A.O.T. Patented
BALTIMORE Patented
1388A G7-64 INDIAN CLUB Patented
1388A G7-64 ISLE ROYALE Patented
LOT 38 G2-22 OMEGA 1st EXT'N. SOUTH Patented
LOT 37 G2-21 OMEGA Patented
ANTELOPE Patented
1388A G7-64 PILOT Patented
1388A G7-64 BRUNSWICK Patented
1388A OWOSKO Patented
1388A G7-64 LITTLE DAVE Patented
1388A G7-64 COPPER FEND Patented
1388A COPPER WORLD Patented
1388A G7-64 TALLY HO Patented
EXCHANGE Patented
1388A G7-64 LEADER Patented
1388A G7-64 WATER WISH Patented
1388A G7-64 NEW MEXICO Patented
1388A G7-64 GRIZZLY Patented

SEC.13, T.18 S., R.15 E.
HELVETIA DIST.

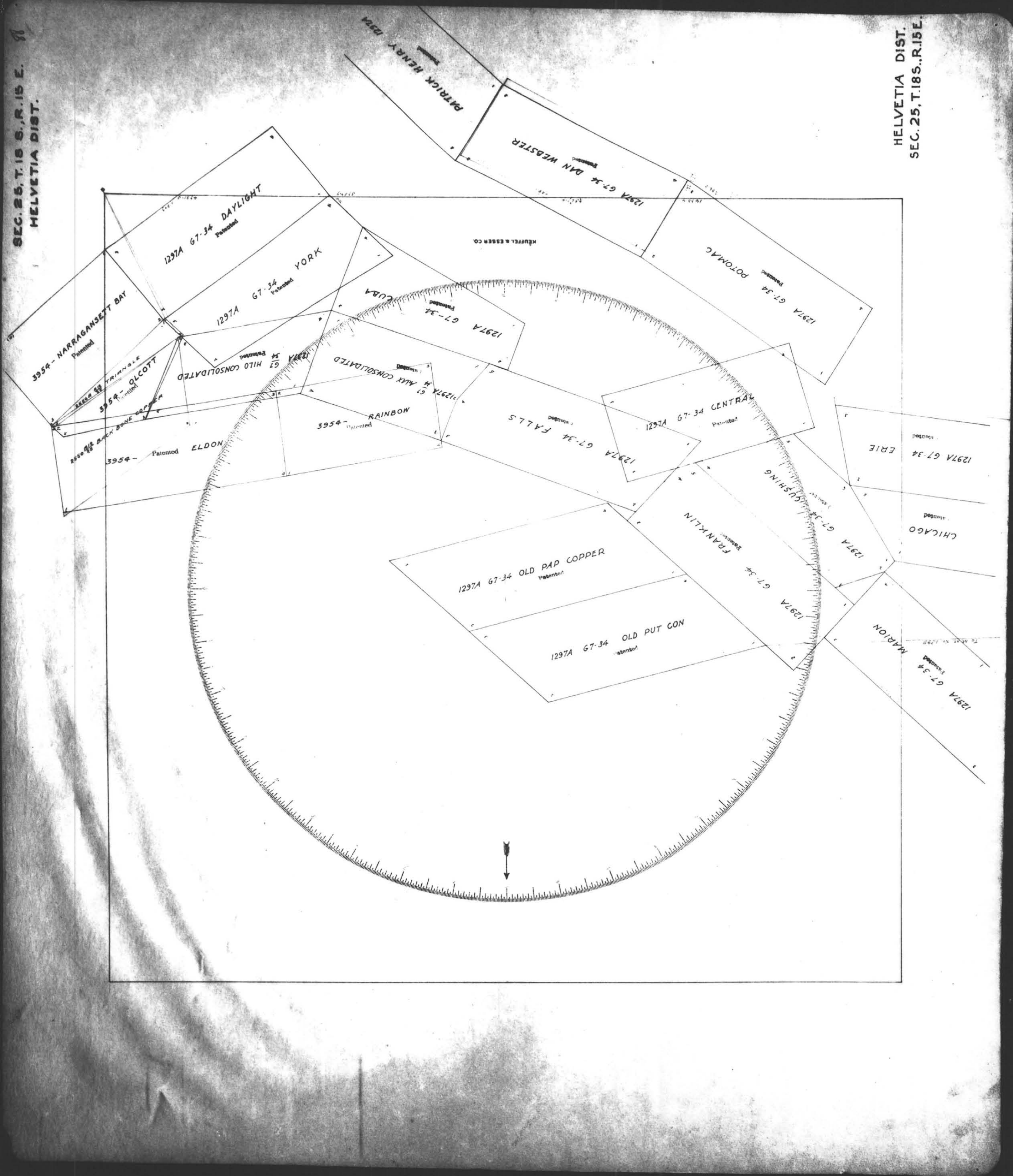
HELVETIA DIST.
SEC.13, T.18S., R.15E.



SEC. 12, T. 18 S., R. 15 E.
HELVETIA DIST.
Surveyed,

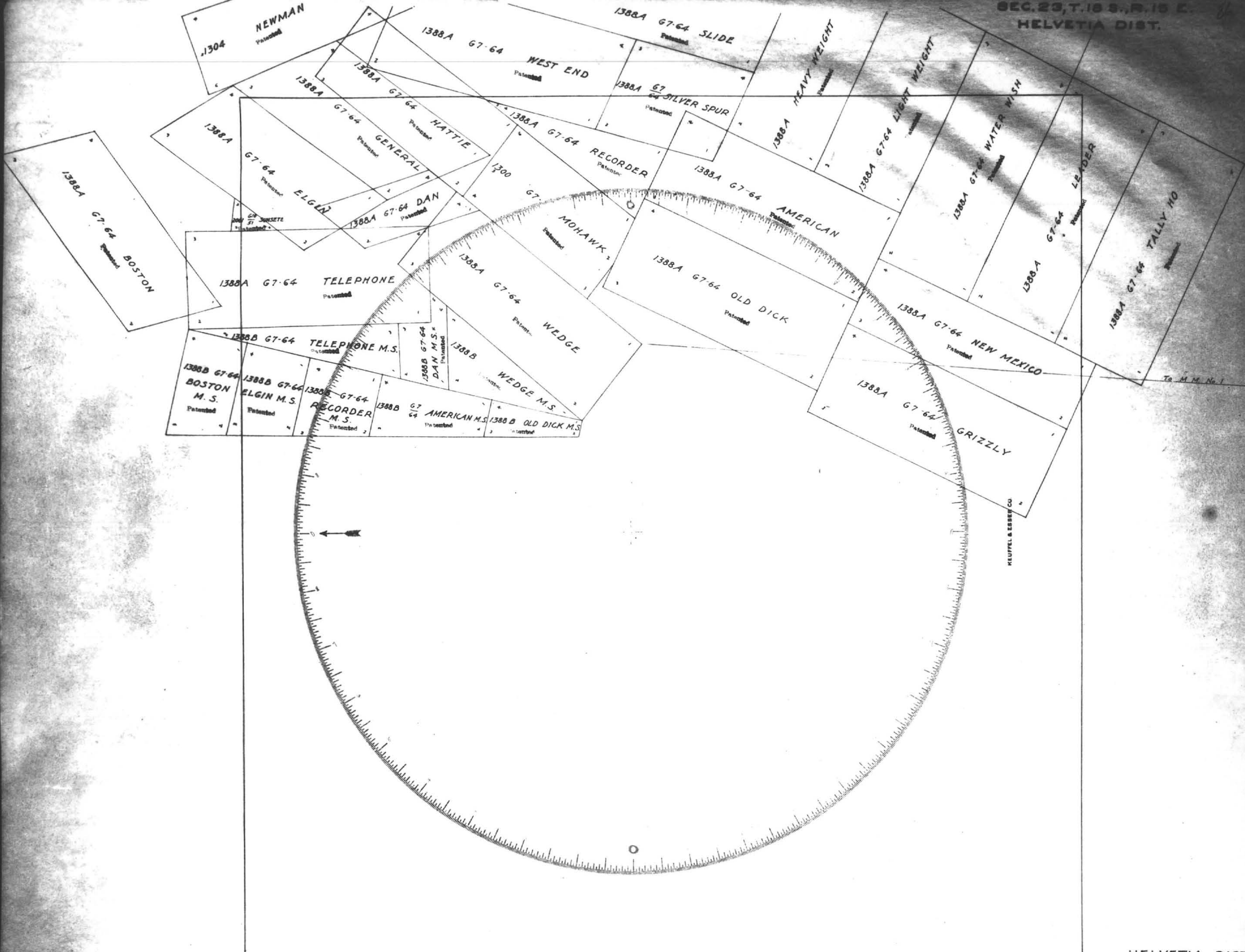


HELVETIA DIST.
SEC. 12, T. 18 S., R. 15 E.



SEC. 25, T. 18 S., R. 15 E.
HELVETIA DIST.
HELVETIA DIST.
SEC. 25, T.18S., R.15E.
PATRICK HENRY
1297A G7-34 DAN WEBSTER
Patented
1297A G7-34 DAYLIGHT
Patented
1297A G7-34 YORK
Patented
3954 - NARRAGANSETT BAY
Patented
1297A G7-34 POTOMAC
Patented
KEUFFEL & ESSER CO.
1297A G7-34 CUBA
Patented
1297A G7-34 HILO CONSOLIDATED
Patented
3954 - OLCOTT
Patented
TRIANGLE
BACK BONE COPPER
1297A G7-34 ALEX CONSOLIDATED
Patented
3954 - RAINBOW
Patented
3954 - Patented ELDON
1297A G7-34 FALLS
Patented
1297A G7-34 CENTRAL
Patented
1297A G7-34 ERIE
Patented
1297A G7-34 CUSHING
CHICAGO
Patented
1297A G7-34 FRANKLIN
Patented
1297A G7-34 OLD PAP COPPER
Patented
1297A G7-34 OLD PUT CON
Patented
1297A G7-34 MARION
Patented

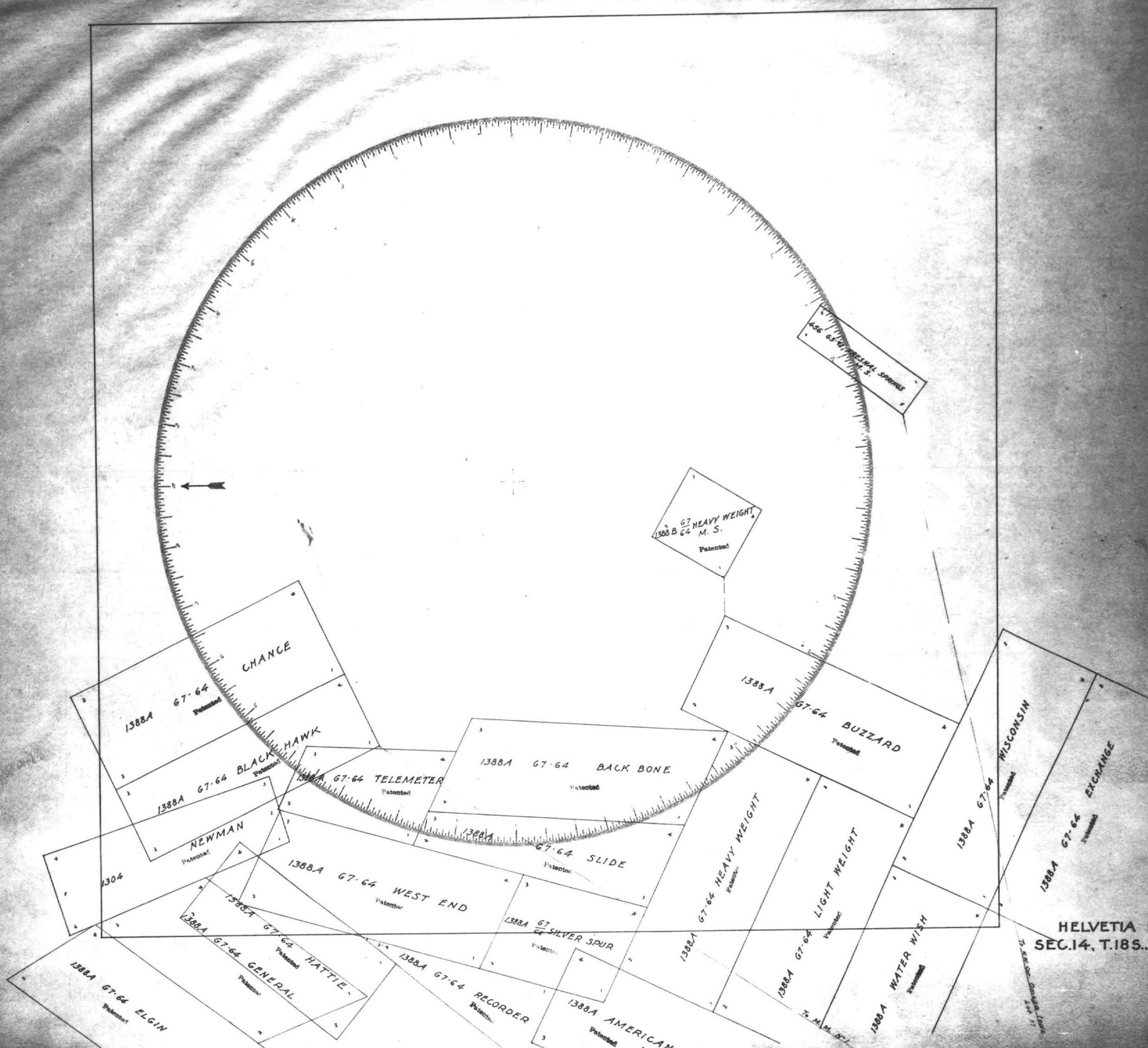
SEC. 23, T. 18 S., R. 15 E.
HELVETIA DIST.



HELVETIA DIST.
SEC. 23, T. 18 S., R. 15 E.

SEC.14, T.18 S., R.15 E.
HELVETIA DIST.

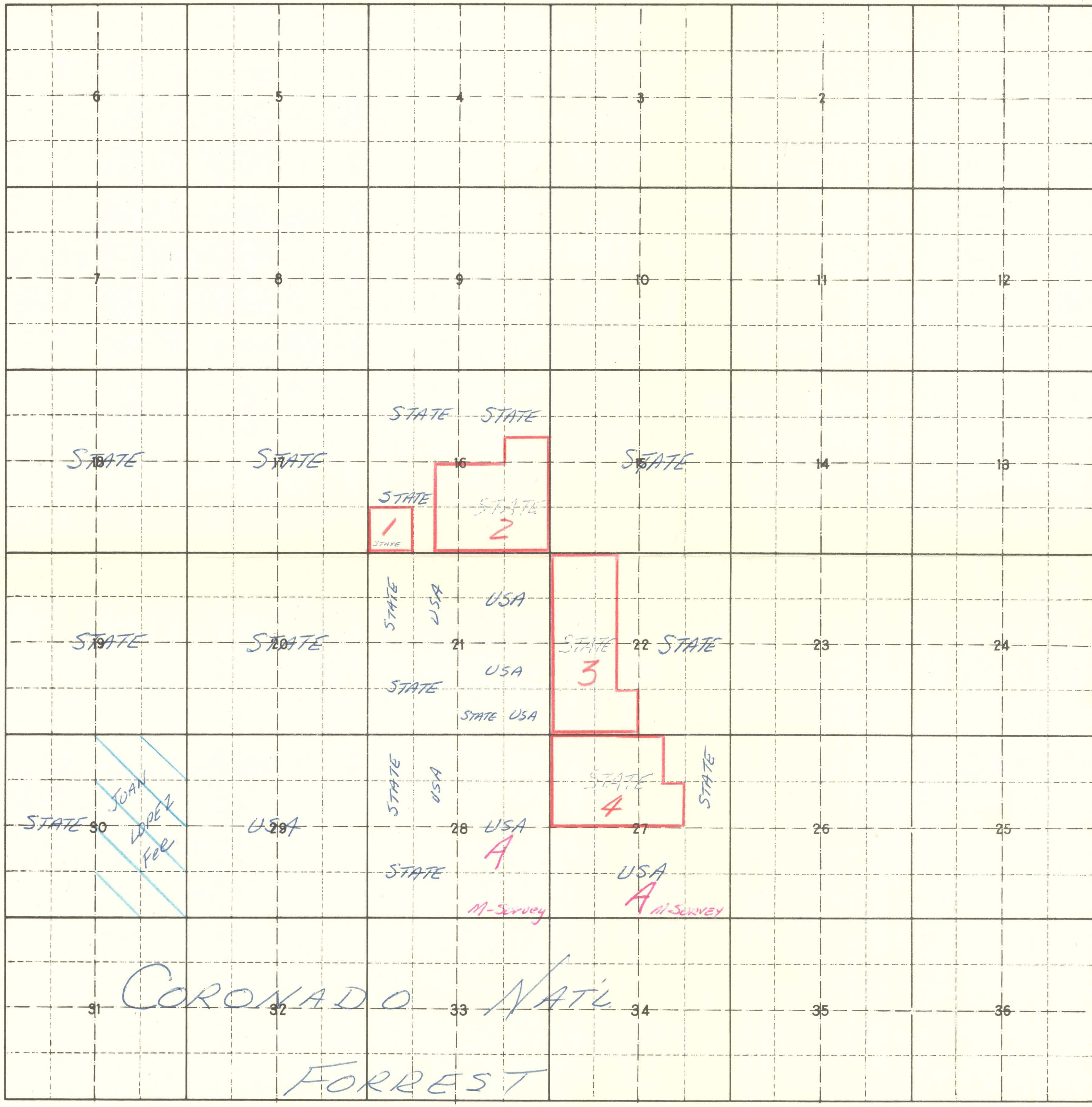
83



HELVETIA DIST
SEC.14, T.18S., R.15

NO SANTA RITA MTNS AREA

TOWNSHIP 17S RANGE 16E COUNTY Pima B. & M.



NOTES—

The Federal parcels other than the patented mining claims are patented lands wherein PATENTEE did not get O&G M.

STATE MINERAL LEASES

1. #606-S Exp. date 1976 SERASIO and CARDILLO

2. #46354-S Exp. date 1969 Walter Bopp

3. #46338-N Exp. date 1969 Walter Bopp

4 #46339-N Exp. date 1969 Walter Bopp

A - See Mineral Surveys of Patented Mining Claims In M.E. Co file—

Represents fee ownership—individual—present day ownership yet to be determined

Pima Co. Arizona
(Author Unknown)

CHAPTER V

Economic Geology

History of Mining in Canada del Oro:

One of the earliest explorers of the Canada del Oro was one Isaac Goldberg[1] alias "Loma de Oro" who in September, 1869, "heard through an escaped captive...a person who had been in infancy carried off by the marauding Apaches, but tired of his unusual associations... came from the Santa Catalina Mountains, and reported that upon the very summit of the Canada del Oro was gold in abundance."

Goldberg continues his story..."I hastily organized a company of explorers and prospectors consisting of P.W. Dooner, General Sigel, Jack Shubling and eight Mexicans...all good citizens. We took one burro laden with a few days provisions, expecting to shortly return with pocketfuls of nuggets. But on reaching our destination, we found, instead of gold pieces, large chunks' of ising-glass..."

It took the party eight days to get to the head of the canyon and back to the "ancient presidio..and sometimes deserted city with buildings mostly in ruins..." (Tucson). He speaks of "almost incredible hardships (which) hindered and encumbered our progress...narrow, steep tracts between dreadful abysses, exhausting tracts of rocky sterility, and patches of 'brush' so thick and thorny that our wearied bodies lost their coverings, and our blistered feet their leather protectors. We were nearly naked, barefoot, and on the brink of starvation..."

P.W. Dooner[2] , one of the party, was at that time editor of the Arizona weekly. In his issue on September 25, 1869, he apologized to the readers for not publishing his paper for two weeks as he was lost in the Canada del Oro. His story of the expedition differed somewhat from Goldberg's account, yet they both agreed that they had discovered a mine. As Goldberg describes it, "the rock from which assayed richly, but the contents yet remain undisturbed, owing to its uncommon inaccessibility. We had, however, attained the distinction of being the first explorers of the terrible precipitous heights known as the Santa Catalina mountains..."

It was fifteen years later that Isaac Goldberg ventured forth into the Canada del Oro again to search for the mine he had discovered. In his search he encountered Apache Indians and thereupon gave up the expedition and left the Arizona Territory.

---

[1]Story of the Pioneer Days of Isaac Goldberg. June, 1894. Written for the Society of Arizona Pioneers.

[2]The Weekly Arizonan September 25, 1869, Editor, P.W. Dooner.

From Goldberg's description of the inhuman cruelties and hideous deaths suffered by the captives of the Apaches, it can easily be seen why prospectors did not venture alone into the Canada del Oro district until late in the 19th century. The Arizona Weekly[1] mentions that prospectors banded together in groups of 20 to 30 men and panned gold along the banks of the lower Canada del Oro in the 1870's.

The first mine to be located within the area under study was named the Bonanza Mine whose addit was started April 5, 1880, by Frank Schultz, P.V. Watson, and B.C. Parker. The location of this mine was recorded[2] in March, 1882, after the area had been surveyed by the United States Department of Mineral Survey.

Below is a copy of the surveyor's field notes given to the writer by an employee of the Stove-Lid Mine. In part it reads:

"I proceeded to the Canon del Oro and after careful and thorough examination of the mineral belt crossed by Seled Canon (location unknown to the writer) on July 2, 1880, I selected a high prominent hill situated on easterly of the aforsaid canyon - about 4 1/2 miles above the old placers --- heavily capped white quartz and centrally located in the mineral belt as the most suitable location an initial point and erected thee a standard which shall be known at 'Mt. Ivenah' U.S.M.M. (The name of this hill has been discarded although the mineral monument is present) described as follows(:)

"Set a white oak post 6' (ffet) high (and) 7" (inches) diameter hewed square and marked on N. side U,S.M.M. on E. side Mt. Ivanah in mound of white quartz rock 4' (feet) by 4' (feet) at base and 4 1/2' (feet) high from which following bearings were taken(:)

"Magnetic variation 13° 7' E

1. Highest point of Mt. (mountain) visible on easterly side of aforesaid canon (canyon) bears S 43° E.
2. Highest point of Mt. (mountain) bears S 88° E. (3 to 5 missing)
6. Main course of Canada del Oro N 51° W.
7. 1st highest point of mountain on lower W. side of Canada del Oro bears N 77° W.
8. 2nd highest point on W side bears S 75° W.
9. (Missing)
10. Ledge of white rock on farthest point on mountain up Canada del Oro bears S 25° E.
11. Center of entrance of Bonanza tunnel bears S 85° W (at) distance (of) 715 1/2' (feet) --- Length of tunnel 111 feet.

(Signed) L. D. Chillson
U. S. Det. M (Mineral) Ser. (Survey)

notes from Ong Joe..." (Unquote)

---

[1]The Arizona Weekly - September 4, 1900 - Arizona Pioneer Society, Tucson, Arizona.

[2]Pinal County Book of Deeds - Page 526, March 28, 1882.

By 1900[1] there were mahy small mines located on the northern side of the Santa Catalina mountains. The actual Canada del Oro district was somewhat vaguely defined, comprising such areas that are now known as Peppersauce Canyong, Marble Peak, Copper Peak, and Mount Rice. Among the operating mines were the Congdon group operated by Sullivan and Oden, Stratton group of E. O. Stratton, the Apache group of R. N. Leatherwood, and the Copper Peak mine operated by M. Geesman (later operated by Grand Central company, then by Congdon Company, and finally by the Phelps Dodge Copper Corporation).

The writer had the pleasure of talking to Mrs. Edith Stratton Kitt, daughter of Emerson O. Stratton, a pioneer miner who located the Stratton claims in 1879. Mrs. Kitt[2] tells of Indian troubles, wars between ranchers, and claim jumpings, much of which she recorded in a memoir of her fathers.

In 1925[3] W. L. Cochrane, a local mine promoter and "expert placer miner" interested a group of Kansas City businessmen in promoting a large scale hydralic placer mining scheme in the lower Canada del Oro. Cochrane claimed he could pan 30 cents worth of gold per cubic yard from the river bed and planned to option 3,300 acres. He estimated that the proposed placer mine would mine 5000 cubic yards of earth per day and that the lifetime of the mine would be over 500 years.

From a newspaper clipping two years later[4] the project was still hanging fire. Will. M. Neal of San Francisco evidently had bought up the options and the Kansas City group, including Mr. Cochrane, were "no longer interested." The project must have been given up later as the writer has never encountered any appreciable water development constructions throughout the course of the Canada del Oro.

ORE DEPOSITS:

(a) General Statement: Within the area under study of the Canada del Oro, the minerals of economic importance are lead, zinc, copper, and minor amounts of silver. In spite of the name "Ravine of Gold" no gold has been found, either in underground mining or in placers for at least 25 years within this area. All economic mineralization is found either shear zones in the pre-Cambrian Mescal limestone or in quartz monzonite porphyry intrusions.

---

[1] Arizona Weekly - September 4,1900 - Arizona Pioneer Society, Tucson, Arizona

[2] Kitt, Edith Stratton - Reminiscence of Emerson Oliver Stratton as told to his daughter, Edith Stratton Kitt, Summer of 1925, Arizona Pioneers' Society, Tucson, Arizona.

[3] Tucson Citizen - August 16, 1925, Arizona Pioneers' Society, Tucson, Arizona.

[4] Tucson Citizen - April 4, 1927, Arizona Pioneers' Society, Tucson, Arizona

(b) CLASSIFICATION OF MINERAL DEPOSITS:

(1) Hypogene deposits: The hypogene mineral deposits of the area may be classified as epithermal deposits after Emmons.[1] They are in or near intrusive rocks consolidated at shallow depths. The introduction of the ore minerals took place during Miocene or later time and the rocks have not been deeply eroded since the ores were deposited. The ores are found as chute in irregular veins with ore pods or in ledges and pod-like deposits. All deposits discovered and worked to date have been small. Characteristic epithermal mineralization included simple sulphides such as pyrite, sphalerite, galena, and chalcopyrite with gangue minerals such as quartz, calcite, and minor amounts of barite. The country rock near the deposits is often extensively altered hydrothermally but no intensive alteration zone has been observed, and the ore is generally deposited in or relatively near fractures.

(2) Supergene deposits: The supergene deposits of the area may be divided into two classes: those enriched by subtraction of valueless material, and those enriched by precipitation of metals. The first class of supergene enrichment will be discussed under the section on the mineralization of the Stove-Lid mine. The ores of the second class of supergene enrichment are oxide and carbonate ores of copper such as cuprite (Ou_2O), malachite ($CuCO_3.Cu(OH)_2$) and azurite ($2CuO_3.Cu(OH)_2$) found in the vicinity of the Lead Reef mine.

(3) The Stove-Lid mine:

(a) General Statement: The Stove-Lid mine (Plate 2) is located in the extreme north central part of the area and is owned and operated by Mr. Robert A. Burney. The underground workings of the mine are located in a fault zone between the northern edge of an abnormally thick block of Mescal limestone that forms the hanging wall of the fault, and highly altered Cambrian Troy quartzite which composes the footwall.

(b) Mineralization: The ore metals of the mine are lead, zinc, and silver. Lead is derived from hypogene galena (PbS) and supergene cerussite ($PbCO_3$). The galena found in the mine occurs in irregular veins and in rich pockets near the falt between the Mescal limestone and the altered Troy quartzite. The pockets of ore occur predominantly in the limestone although a few irregular deposits have been found in the quartzite close to the fault zone. The galena is generally of the micro-crystalline type although in the northeastern end of the stope level (Plate 2) of the mine. It appears as a reddish brown to balck earthy deposit within the fault zone and is characterized by its high specific gravity and effervescence in dilute nitric acid. The cerussite has been produced by the action of carbonate waters upon the primary galena.

---

[1] Emmons, William H. - Principles of Economic Geology, McGraw Hill, pp. 68-74, 1940.

Sphalerite (ZnS) is the economic mineral next in abundance to cerussite. It appears as a greenish brown mineral with resinous luster that streaks a light greenish brown. It is usually intermixed with galena but in places occurs as isolated veins in this mine. To date it has not been found in the lower level of the mine, probably due to the leaching effect of hte same carbonate waters which produced the cerussite mentioned above and which carried the zinc away in solution.

Silver occurs in the galena, presumably in solid solution, as no evidence of the presence of silver minerals could be detected in polished section. Statistical data concerning percentages of silver are unavailable at the present writing, but are reported to vary in inverse ratio to the grain size of the galena, the higher silver values occurring in the micro-crystalline material. Silver is unknown in the cerussite or shalerite.

No other economic minerals have been found in the mine. The gangue minerals are calcite, barite, pyrite, and limonite.

(c) Paragenesis: The order of deposition of the various minerals from a study of several polished sections indicated that calcite was the first mineral to be deposited and was in part replaced by, galena. Sphalerite replaces both calcite and galena. All three of the afore mentioned minerals are replaced by pyrite. Quartz was the last mineral to be deposited (Figure 4).

(d) Structure: The structure controlling the deposition of the ore is a large thrust fault zone striking NE - SW, and dipping from 45 to 55 degrees SE. (Plate 2) No single fault has been traced from the tunnel level to the bottom level, but several faults of similar strike and dip are observed on all three levels. The vertical displacement of any of the faults in this zone is unknown. By close inspection of the gouge and slickensides in the drifts of the tunnel level and the hanging wall in the stope it appears that the latest movement along the faults was a strike slip movement of unknown displacement. The thrust faulting was followed by normal faulting. On the footwall side of the drift near the tunnel level station of the inclined shaft several blocks exhibit normal faults with displacements of from 5 to 10 feet.

A structurally complex area in the mine occurs at the northeastern end of the bottom level. The ground is highly shattered and gougey and the fault pattern and fault movements are not clear. The expression of this complex area is not shown in the stope level above.

(e) Mining Method Used in the Stove-Lid Mine:
Because of the relatively strong hanging wall and the high angle of dip of the ore bearing veins an underhand stoping method such as is described by Young[1] is used. In this method a winze is sunk from one drift level to the next lower drift level. Stoping then commences on the top level, the ore is passed down the winze and drawn off at thebottom and hoisted to the surface. Mr. Burney, the owner-operator of the mine, found this method to be advantageous because of the control of ore breakage possible, and because of the low timber costs, as very little timber is needed to support the strong footwall.

---

[1] Young, George J. - Elements of Mining, MCGraw Hill, p. 497, 1923.

(f) Future Outlook of the Mine: Although statistics concerning the production of the mine or the assays of the longholes (Plate 2) are not available for publication at the present writing, it is the writer's personal opinion that ore production from the mine can be increased and that further exploration and development to the southwest and especially at greater depths is warranted.

File Pima County

Middle Tertiary plutonism in the Santa Catalina

and Tortolita Mountains, Arizona

By

S. C. Creasey, Norman G. Banks, R. P. Ashley, and Ted G. Theodore
U.S. Geological Survey, Menlo Park, California 94025

U.S. Geological Survey
Open-file Report 76-262
1976

CONTENTS

ILLUSTRATIONS

TABLES

ABSTRACT

Recent reconnaissance geologic mapping in the Santa Catalina and Tortolita Mountains of southeastern Arizona, supplemented by new and published potassium-argon and fission-track ages, suggests that a large middle Tertiary (about 25 m.y.) composite batholith crops out extensively in both mountains. More than two-thirds of the batholith and the contiguous wallrocks are gneissic, the gneissosity comprising strong cataclasis and mylonitization, penetrative planar and linear structures, and crystallization of muscovite and biotite in the foliation planes. New radiometric ages indicate the deformation followed the crystallization of the batholith so closely that the K-Ar dating method cannot distinguish a difference, whereas previously published ages from the gneisses indicate a short time interval between the two events.

INTRODUCTION

The authors recently mapped the geology of the Santa Catalina and a small part of the Tortolita Mountains in reconnaissance (Banks, 1976; Creasey and Theodore, 1975), and made 26 new radiometric age determinations to help interpret the plutonic and structural history of the region. A synopsis of the geology of the Santa Catalina Mountains, which includes some heretofore unpublished geology of the northern flank of the mountains, is shown on figure 1.

The Santa Catalina Mountains were mapped twice by the U.S. Geological Survey previous to our work, but neither of the earlier maps were published. The first map was made by C. F. Tolman, Jr., at a scale of 1:125,000 in 1911-12. He also prepared a report in 1914, but neither map nor report was published. In 1930, B. N. Moore of the U.S. Geological Survey was assigned to update the report for publication. In 1938, he submitted a report, but before the report was approved for publication, he left the Geological Survey, and again the report was never published. However, a summary of Moore's report, prepared by B. S. Butler and R. M. Hernon, and a black-and-white version of the map were released in open file (Moore and others, 1949). In addition, many maps from theses by students from the University of Arizona cover separate parts of the Santa Catalina. Except for a mid-Tertiary rather than a Late Cretaceous or early Tertiary age for emplacement of the batholith and development of the gneiss, our interpretations do not differ substantially from those of B. N. Moore.

New K-Ar and fission-track ages are listed in table 1, and to permit comparison, previously published K-Ar and Rb-Sr ages of rocks in the Santa Catalina Mountains are listed on tables 2 and 3. These data are summarized by the bar graphs of figures 3 and 4. Chemical and spectrographic analyses, modes, and norms of our dated rocks and two additional samples are listed at the end of the report (table 4). The locations of all samples, including ours and those available for dated samples reported in the literature are indicated on figure 2. The analytical data supporting the radiometric ages are tabulated at the end of the report.

GENERAL GEOLOGY

The Santa Catalina Mountains are one of the structurally and lithologically complex mountains of the Basin and Range province in southeastern Arizona (fig. 1). At the northern end of the Santa Catalina, the Mogul fault is the dominant structure. North of the Mogul fault, only Oracle Granite, locally cut by dikes and quartz veins, crops out, whereas south of the fault and along the northeastern flank, the range consists of Precambrian, Paleozoic, and Mesozoic sedimentary rocks, all intruded by quartz diorite, quartz monzonite, and granodiorite porphyry.

The central core of the Santa Catalina Mountains consists of a large composite batholith of middle Tertiary age. Apparently the batholith extends to the northwest into the Tortolita Mountains, where it has been partly mapped in reconnaissance by the authors, and to the southeast into the Rincon Mountains. The batholith comprises at least two intrusive phases hereafter referred to as the quartz monzonite of Samaniego Ridge and the quartz monzonite of the Tortolita Mountains. Except for two dikes of the quartz monzonite of the Tortolita Mountains, just east of the Pirate fault, only the quartz monzonite of Samaniego Ridge crops out in the Santa Catalina Mountains. The main mass of the quartz monzonite of the Tortolita Mountains lies to the west of figure 1 in the Tortolita Mountains.

The southwestern flank of the Santa Catalina consists of a mixture of quartz monzonite of Samaniego Ridge and roof pendants, principally of Oracle Granite, but also of granodiorite and Precambrian rocks. The quartz monzonite forms a sill-like body more than 2 km thick which intruded the contact between the Apache Group composed of sedimentary rocks lying to the north and the Oracle Granite on the south.

Roof pendants and xenoliths of Apache Group, Pinal Schist, Paleozoic and Mesozoic sedimentary rocks, and quartz diorite (Leatherwood) occur here and there in the quartz monzonite. They are common near Mount Lemmon, which is the highest peak in the Santa Catalina.

Emplacement of the batholith was essentially coeval with the development of extensive penetrative planar and linear structures that characterize the gneisses forming the southeastern forerange of the Santa Catalina Mountains and extending both northwestward into the Tortolita Mountains and southeastward into the Rincon Mountains, which join the Santa Catalina Mountains along a low divide known locally as the Redington Pass. The contact between gneissic and nongneissic parts

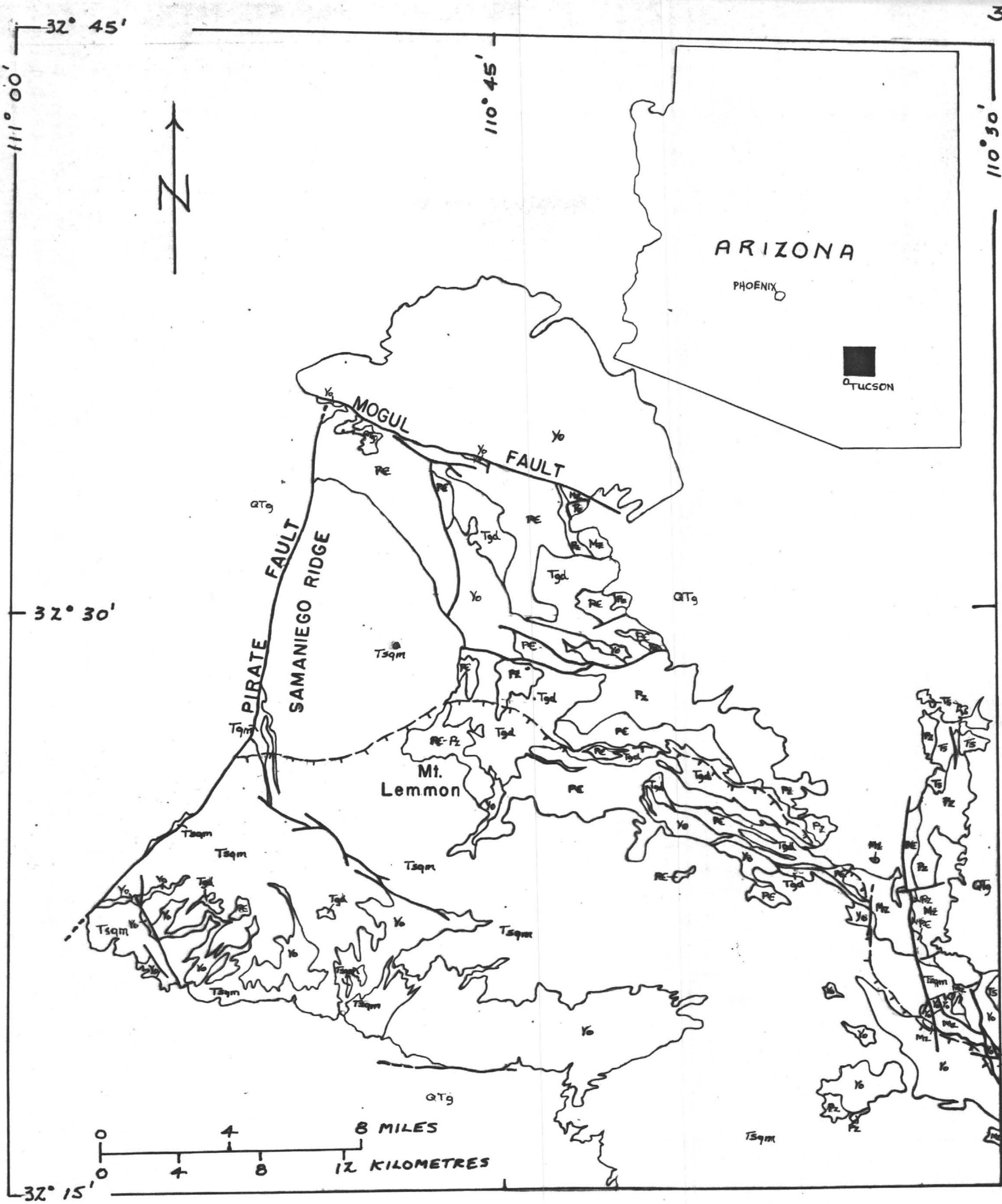


Figure 1.--Geologic sketch map of the Santa Catalina Mountains.

EXPLANATION FOR FIGURE 1

QTg	Quaternary and Tertiary sedimentary rocks: sand, gravel, conglomerate, sandstone, lake deposits
Ts	Tertiary sedimentary rocks: redbeds, shales, sandstones, conglomerates, minor volcanics near east edge of map
Tqm	Quartz monzonite of the Tortolita Mountains: fine- to medium-grained equigranular dikes. Probably correlative with similar rocks in the Tortolita Mountains
Tsqm	Quartz monzonite of Samaniego Ridge; includes porphyritic and equigranular phases and large areas with abundant xenoliths of Precambrian Y Oracle Granite of Peterson (1938)
Tgd	Quartz diorite (Leatherwood), granodiorite, granodiorite porphyry
Mz	Mesozoic sedimentary rocks: limestone, sandstone, shale, conglomerate
Pz	Paleozoic sedimentary rocks: includes Naco Limestone, Escabrosa Limestone, Martin Formation, Abrigo Formation, Bolsa Quartzite
P€	Precambrian X Pinal Schist and Precambrian Y Apache Group: Includes areas (P€-Pz) near Mt. Lemmon of mixed Apache Group and Paleozoic rocks
Yo	Precambrian Y Oracle Granite of Peterson (1938): older than Apache Group
	Fault
	Approximate location of gradational contact between foliated and nonfoliated rocks. Foliated rocks on the side with the barbs.

of the batholith is gradational. The approximate location on the contact is shown on figure 1.

The fabric of the northward-extending mass of the batholith east of the Pirate fault and north of the gneissic front near Cargadero Canyon is typically igneous: the rock is massive except for joints and sparse aplite dikes. Textures are porphyritic with a medium-grained hypidiomorphic groundmass, and locally near the northeastern margin of the batholith equigranular hypidiomorphic granular. In this part of the batholith, penetrative deformation and rock alteration are absent, suggesting no subsolidus reheating. Because the minerals dated are unchanged since crystallization, our radiometric ages from this area (table 1 and fig. 2) are the prime basis for our interpretation of the age of crystallization and the cooling history of the batholith.

In contrast, the rocks forming the gneissic parts of the batholith show strong cataclasis and mylonitization, and in the foliation planes, secondary muscovite and some secondary biotite abounds; primary biotite may also have been rotated into the movement planes. The rock is metamorphic, the deformation penetrative, and the rock types are gneisses and schists.

The distribution of the gneissic and nongneissic parts of the batholith is locally erratic. Although most of the batholith shown on figure 1 is gneissic, patches of relatively massive quartz monzonite occur within the gneissic area, particularly in the southeast part of the area of figure 1. Some of the deformation extends as much as 3 km beyond the limits of the batholith. The sedimentary rocks adjacent to the batholith along the northern flank of the mountains have been so intensely sheared and recrystallized that the original formations generally cannot be distinguished from one another. Here, too, the contact between sheared and unsheared sedimentary rocks is gradational. In the nongneissic terrane, comparatively few aplite and pegmatite dikes occur. In the gneissic terrane, however, both the intrusive and country rocks contain locally abundant pegmatite dikes, some of which are foliated, but others are massive.

RADIOMETRIC AGES

Potassium-argon and fission-track ages (tables 1 and 2) of unaltered and undeformed minerals from the quartz monzonite of Samaniego Ridge indicate an apparent middle Tertiary age of crystallization of the batholith; they also give some information on the cooling history. The age of deformation is more ambiguous. Our new ages, which are from one biotite-muscovite mineral pair derived from deformed quartz monzonite, suggest deformation followed crystallization of the quartz monzonite so closely that no age difference is discernible between gneissic and nongneissic phases (table 1). However, the published K-Ar

Table 1.--*New fission-track and K-Ar ages of the quartz monzonite of Samaniego Ridge and the quartz monzonite of the Tortolita Mountains, from the Santa Catalina and Tortolita Mountains*

[Analysts: S. C. Creasey, K-Ar; R. A. Ashley, fission track]

Loc. fig.	Sample no.	Mineral dated	Method	Apparent age	Rock type	Location	Comments
II	GGN-S1	Biotite	K-Ar	22.7±0.7	Quartz monzonite of Samaniego Ridge	32°22' N. 110°43' W.	Gneissic
		Muscovite	K-Ar	24.1±0.7			
		Apatite	F.T.	18.7±2.7			
IV	ML-61	Biotite	K-Ar	24.0±0.7	Quartz monzonite of Samaniego Ridge	32°27.5' N. 110°52' W.	Massive, porphyritic with medium-grained hypidiomorphic granular groundmass
		Hornblende	K-Ar	22.3±0.7			
		Apatite	F.T.	20.2±2.1			
		Zircon	F.T.	26.3±3.4			
		Sphene	F.T.	27.5±3.1			
IV	ML-60	Biotite	K-Ar	23.5±0.7	Mafic inclusion	32°27.5' N. 110°53' W.	Original rock formation is uncertain
		Hornblende	K-Ar	36.1±1.0			
		Apatite	F.T.	20.7±2.5			
		Sphene	F.T.	27.9±3.7			
VII	BR-21	Biotite	K-Ar	23.1±0.7	Quartz monzonite of Samaniego Ridge	31°31.5' N. 110°50' W.	Massive, porphyritic with medium-grained hypidiomorphic granular groundmass
		Hornblende	K-Ar	23.4±1.2			
		Apatite	F.T.	22.8±2.8			
		Zircon	F.T.	28.1±3.3			
		Sphene	F.T.	29.1±3.0			
VIII	BR-16	Biotite	K-Ar	23.2±0.7	Quartz monzonite of Samaniego Ridge	32°31.5' N. 110°48' W.	Massive, medium-grained hypidiomorphic granular
		Apatite	F.T.	19.8±2.1			
		Zircon	F.T.	25.1±2.5			
		Sphene	F.T.	27.2±3.1			
---	RC3-1	Biotite	K-Ar	20.6±0.6	Quartz monzonite of Samaniego Ridge	32°29.5' N. 111°04' W.	Ages probably reset by gneissic dikes of quartz monzonite of Tortolita Mountains. Location not on figure 4. Sample from Tortolita Mountains
		Hornblende	K-Ar	21.1±0.6			
---	RC-25	Biotite	K-Ar	22.1±0.7	Quartz monzonite of Tortolita Mountains	32°28' N. 111°02' W.	Sample from Tortolita Mountains. Location not on figure 4
		Apatite	F.T.	18.0±2.4			
VI	ML-105	Apatite	F.T.	16.5±2.1	Quartz monzonite of Tortolita Mountains	32°27.5" N. 110°58' W.	Massive, slight foliation, fine-grained hypidiomorphic granular

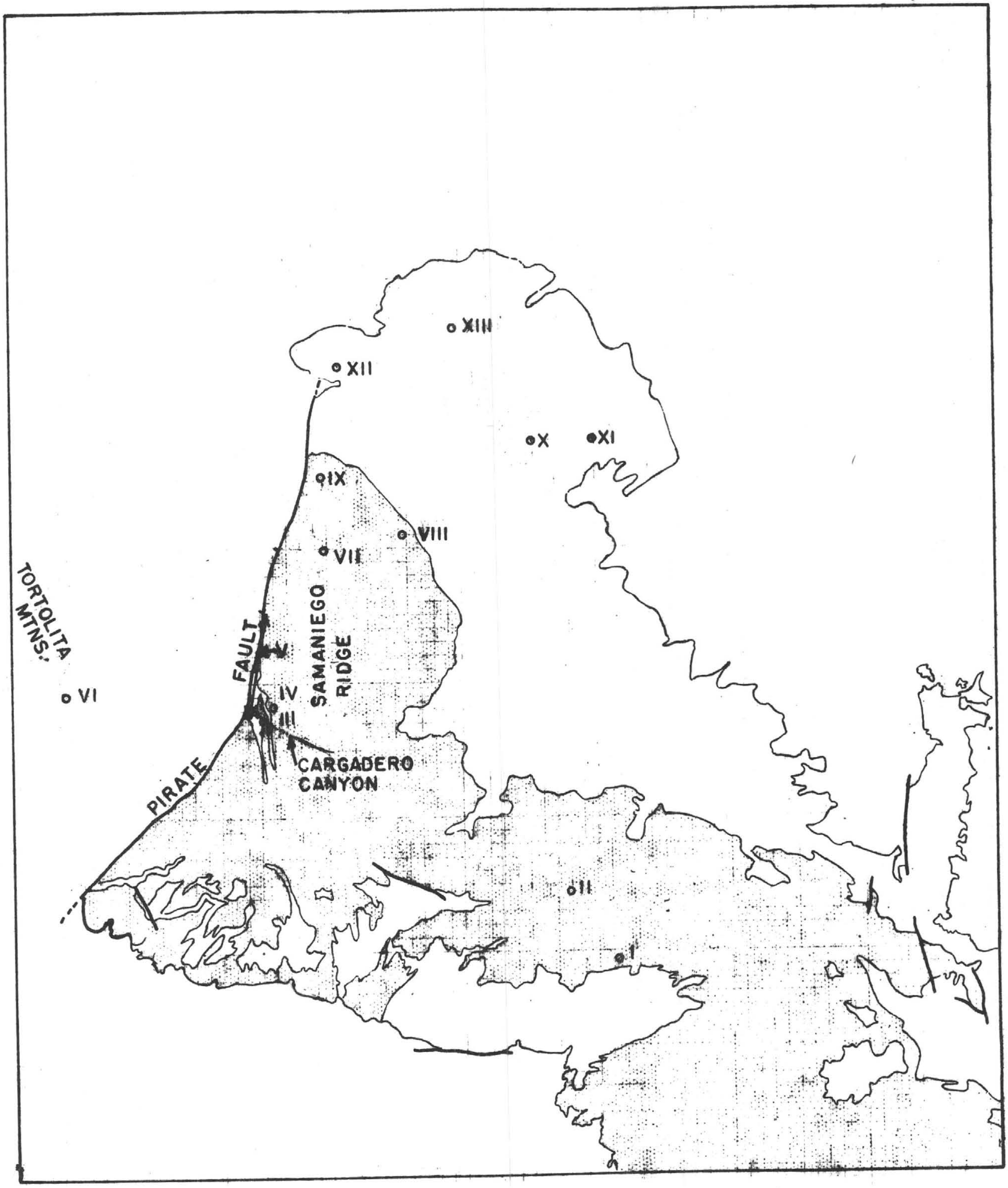


Figure 2.--Locations of samples listed in tables 1, 2, and 3. Stipple pattern indicates the outcrop area of the quartz monzonite of Samaniego Ridge.

Table 2.--*Previously published K-Ar ages of the quartz monzonite of Samaniego Ridge, Oracle Granite, and gneissic rocks, Santa Catalina and Tortolita Mountains*

Location, figure	Sample no.	Mineral dated	Apparent age (m.y.)	Rock type	Location	Reference
III	PED-16-59	Biotite	25.0±3	Quartz monzonite of Samaniego Ridge	Approximately 32°26.5' N. 110°52.2' W.	Damon and others (1963)
III	PED-17-59	Biotite	24.0±3	Quartz monzonite of Tortolita Mountains[1]	Approximately 32°26.5' N. 110°52.2' W.	Damon and others (1963)
II	PED-4a-58	Biotite	24.8±1.0	Gneissic rock	32°22.1' N. 110°43' W.	Damon and others (1963) Mauger and others (1968)
II	PED-4a-58	Muscovite	29.5±0.9	Gneissic rock	32°22.1' N. 110°43' W.	Mauger and others (1968) Damon and others (1963)
II		Muscovite	32 ±3	Gneissic rock	32°22.1' N. 110°43' W.	Catanzaro and Kulp (1964)
I	PED-18-62L	Muscovite	25.4±1	Gneissic rock	32°20.3' N. 110°41.4' W.	Livingston and others (1967) Mauger and others (1968)
I	PED-18-62L	Biotite	25.1±1.0	Gneissic rock	32°20.3' N. 110°41.4' W.	Livingston and others (1967) Mauger and others (1968)
I	PED-18-62L	Orthoclase	26.8±0.8	Gneissic rock	32°20.3' N. 110°41.4' W.	Livingston and others (1967) Mauger and others (1968)
I	PED-18-62L	Plagioclase	[2]29.3±1.0	Gneissic rock	32°20.3' N. 110°41.4' W.	Livingston and others (1967) Mauger and others (1968)
I	PED-18-62D	Biotite	27.5±0.9	Gneissic rock	32°20.3' N. 110°41.4' W.	Mauger and others (1968)
Uncertain	PED-4-58	Muscovite	25.9±1.1	Gneissic rock	Sabino Canyon	Damon and others (1963) Mauger and others (1968)
I	PED-56-66	Muscovite	31.2±0.9	Gneissic rock	32°20.6' N. 110°55.4' W.	Mauger and others (1968)
Uncertain	RM-1-66	Muscovite	31.2±0.9		Unknown	Mauger and others (1968)
IX	PED-27-57	Biotite	38.5±3	Quartz monzonite of Samaniego Ridge	South of Mogul fault	Damon and others (1963)
Uncertain		Whole rock	20.5±3	Trachyte dike	Ventana Canyon	Shakel (1974)
XII	PED-1-58	Biotite	49.2±3	Oracle Granite	Approximately 32°35' N. 110°50' W.	Damon and others (1963)
XIII	PED-3-58	Pegmatite Muscovite	1420 ±40	Oracle Granite	Near Oracle, Arizona	Damon and others (1963)
XI	PED-2-58	Biotite	1420 ±40	Oracle Granite	Approximately 32°33' N. 110°43' W.	Damon and others (1963)
	PED-20-62	Biotite	27.3±0.9	Gneissic rock	32°28.8' N. 111°05' W.	Mauger and others (1968)

[1]Described as a fine-grained granite. Probably the quartz monzonite of the Tortolita Mountains, but could be a younger aplite.

[2]Livingston and others (1967) and Mauger and others (1968) believe this figure does not indicate the age of the rock.

ages, which were obtained from 10 samples of either biotite or muscovite from three localities in foliated rock (table 2), are discernibly older than the age of crystallization; this age difference will be discussed later.

K-Ar isotopic ages from biotite and hornblende, samples ML-61 and BR-21, and from biotite, samples ML-60 and BR-16, are concordant; the range, including the ranges of analytical uncertainty for all the individual ages, is from 21.6 to 24.7 m.y., the mean is 23.3 m.y., and the middle point of the range is 23.2 m.y. Biotite from sample PED-16-59 (table 2) is essentially the same (25.0±3 m.y.) considering the larger stated analytical error.

Concordant ages of two biotite-hornblende mineral pairs and the concordance between the two pairs, which are from different localities (samples ML-61 and BR-21), strongly indicate the age of crystallization. Biotite and hornblende have different argon retention properties, and it is highly unlikely that their ages would agree if the rock had been reheated subsequent to crystallization, unless the heating was so severe that all radiogenic argon was dispelled from both minerals. Such reheating, however, would leave other manifestations of alteration, which are not present.

Hornblende from sample ML-60 (table 1) has a K-Ar age of 36.1±1 m.y. It is one of a mineral pair of which the other is biotite with a K-Ar age of 23.5±0.7 m.y. Sample ML-60 is a mafic inclusion in the quartz monzonite of Samaniego Ridge. Because the biotite age agrees with several other K-Ar ages, including mineral pairs, we hold that it has been completely equilibrated to the age of the quartz monzonite host. We do not know whether the older age of the hornblende is due to excess argon from a local abnormally high, partial pressure of argon in the quartz monzonite, or whether it is due to partial retention of the radiogenic argon that was generated in the rock prior to intrusion of the batholith and prior to the thermal metamorphism of the inclusion by the quartz monzonite magma.

The quartz monzonite of the Tortolita Mountains is the equigranular younger phase of the composite batholith. It intrudes the porphyritic quartz monzonite of Samaniego Ridge in the Tortolita Mountains, and dikes of the equigranular phase cut the porphyritic Samaniego in Cargadero Canyon in the Santa Catalina Mountains. Two K-Ar biotite ages of the quartz monzonite of the Tortolita Mountains, as given by sample RC-25 (table 1) and perhaps by sample PED-17-59 (table 2) are 22.1±0.7 and 24.0±3 m.y., respectively. The range in age of the two samples overlap in part, and until more ages are determined, our best estimate of the age of the quartz monzonite is between 21 and 25 m.y. Rock sample RC-3-1, which is gneissic porphyritic quartz monzonite of Samaniego Ridge, was collected within 1 metre of dikes of the equigranular younger phase of the batholith. A biotite-hornblende mineral pair (sample RC-3-1, table 1) from this rock sample gives K-Ar age of 20.6±0.6 and 21.1±0.6 m.y., respectively. We believe (1) that these ages were reset by the heat of the dikes and therefore reflect the age of the quartz monzonite of the Tortolita Mountains, and (2) that the quartz monzonite of the Tortolita Mountains, although a part of the composite batholith, is perceptibly younger than the quartz monzonite of Samaniego Ridge, using the K-Ar dating technique. The fission-track ages on apatite (samples RC-25 and ML-105, table 1), which will be discussed later, support this contention.

The new K-Ar ages of metamorphic biotite and muscovite (sample GGN-S1, table 1) from the gneissic quartz monzonite of Samaniego Ridge are 22.7±0.7 and 24.1±0.7 m.y., respectively. Their average age (23.4 m.y.) and range (22.0-24.8) are essentially the same as the average age and range for igneous biotite and hornblende from the massive quartz monzonite. These ages, however, differ from the previously published ages of metamorphic biotites and muscovites, which range from 23.8 to 35 m.y., including analytical error ranges for lowest and highest ages; their average age is 27.6 m.y. (gneissic rocks of table 2). We have no adequate explanation for the difference between our ages and the previously published ages. A possible explanation might be related to the proximity of some of the earlier sampled gneisses to outcrops of Oracle Granite (locality I, fig. 2). This, however, could not explain the age differences of the samples collected at locality II. Within the ages previously published of micas from gneissic rocks, the average age of the four biotites is 26.1 m.y. and of the five muscovites is 28.8 m.y. We also have no data to explain this difference, but Mauger, Damon, and Livingston (1968, p. 586) believe that the older age of the muscovite is due to excess inherited argon trapped in large grains. Among the dated muscovite samples, the coarser the grain size, the older the apparent age.

The fission-track ages (table 1) are internally consistent, and suggest that the batholith cooled slowly over a relatively long period of time. From annealing studies (Fleischer and others, 1965; Naeser and Faul, 1969; Calk and Naeser, 1973; Naeser, 1976), which indicate the temperatures at which the minerals begin to accumulate tracks, apatite should indicate the youngest age followed by zircon and sphene. For the massive quartz monzonite of Samaniego Ridge, the average age and the range, including analytical error, for apatite is 20.9 and 17.7-25.6 m.y., for zircon 26.5 and 22.6-31.4 m.y., and for sphene 27.9 and 24.1-32.1 m.y. (table 1 and fig. 2). As an approximation, the cooling history of the samples should reflect that of the batholith, and on this basis, these ages suggest that the batholith had cooled to about 500°C about 28 m.y. ago and had reached about 100°C about 21 m.y. ago. The average age of 26.5 m.y. for zircons suggests that zircon began to accumulate tracks at a somewhat lower temperature than sphene. The

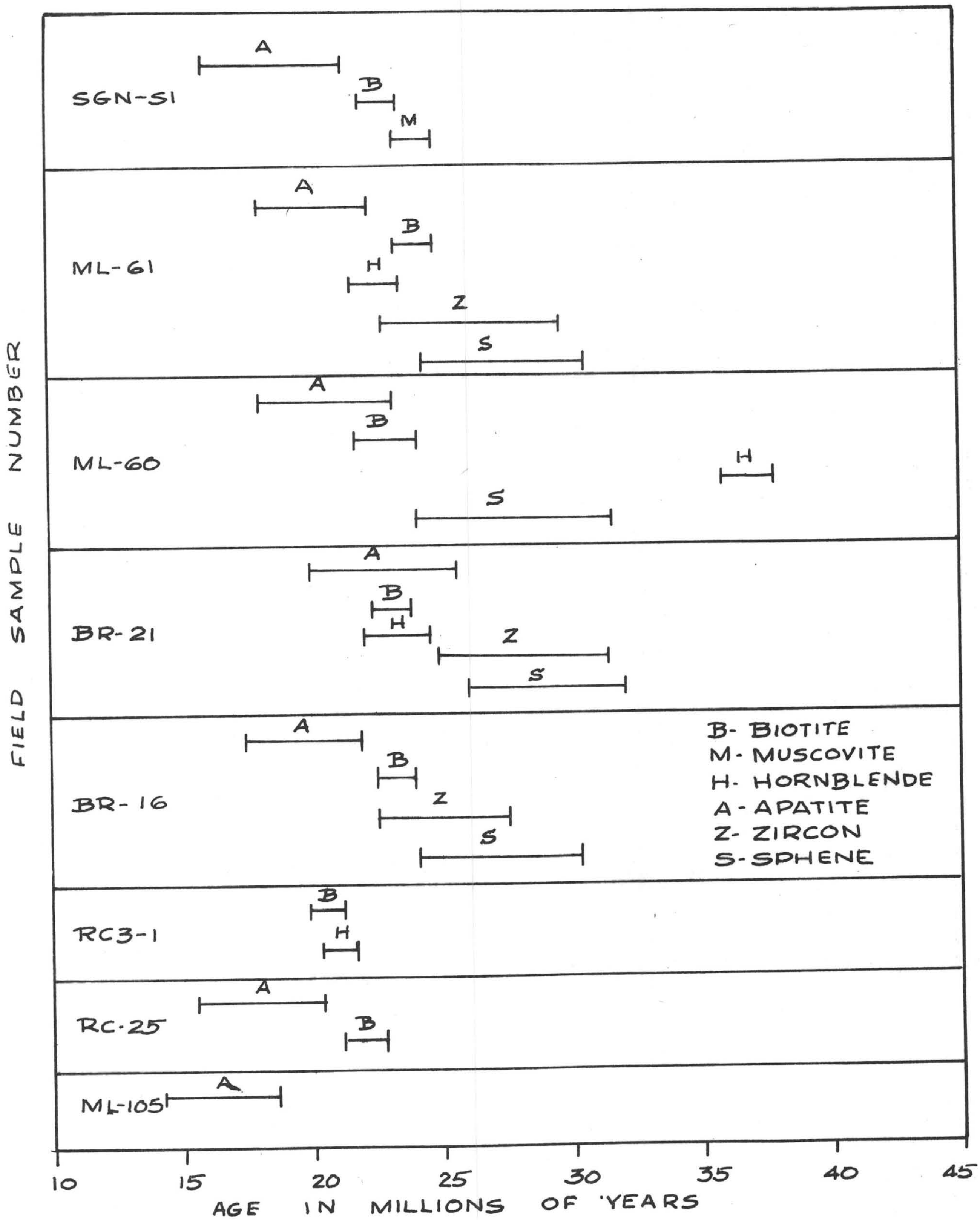


Figure 3.--Bar graphs of new fission-track and K-Ar ages of the quartz monzonite Samaniego Ridge and the quartz monzonite of the Tortolita Mountains, Santa Catalina and Tortolita Mountains.

biotite and hornblende K-Ar ages, however, indicate more rapid cooling. If there is a protracted cooling history, hornblende should begin to collect radiogenic argon before biotite. To judge the cooling history from the fission-track ages, the hornblende should yield ages slightly older than biotite. Actually the biotite and hornblende indicate the same ages, which implies that the temperature of the cooling batholith dropped through the argon retention temperatures of hornblende and biotite so rapidly that the K-Ar method cannot detect any difference between their ages. The data from the two techniques, taken together, suggest that the cooling and crystallization history is more complex than is indicated by either method alone. We have no data, on the other hand, that allows us to delineate the complexities.

The apatite fission-track age for the gneissic quartz monzonite of Samaniego Ridge is 18.7±2.7 m.y., which is slightly younger than the average for the massive phase. For the quartz monzonite of the Tortolita Mountains, the average of two apatite ages is 17.3 m.y., and the range, including analytical error, is 14.4-20.4 m.y. This average age is 3.6 m.y. younger than the 20.9 average ages for apatites from the massive porphyritic Samaniego. This younger average age is supported by the three K-Ar ages for samples RC-3-1 and RC-25, which average 21.3 m.y., 2 m.y. younger than the average for massive Samaniego, and by field relations that show the Tortolita phase intrudes the Samaniego.

Notwithstanding the differences in ages from different dating methods and the differences of our ages from those previously published, examination of figures 3 and 4 shows a magmatic and deformational event occurred about 25 m.y. ago. Our data suggest that the time interval between plutonism and intense deformation was too short for the K-Ar dating method to distinguish, whereas the previously published K-Ar ages suggest the deformation may have followed plutonism by about 4 m.y. based on the average age of muscovite and biotite from gneissic rocks. In either case, plutonism and intense deformation are significantly close together.

We have not determined Rb-Sr ages, but published Rb-Sr ages apparently are not internally consistent even for samples from the same locality (table 3). These data are not sufficient to be interpreted properly, and other published Rb-Sr data for the Santa Catalina Mountains are equally difficult to interpret (Shakel, 1974), suggesting that an in-depth Rb-Sr study coupled with careful geologic control of sampling, might be prudent prior to attempting explanation of discrepancies in the existing Rb-Sr data and differences between Rb-Sr data and K-Ar and fission-track data.

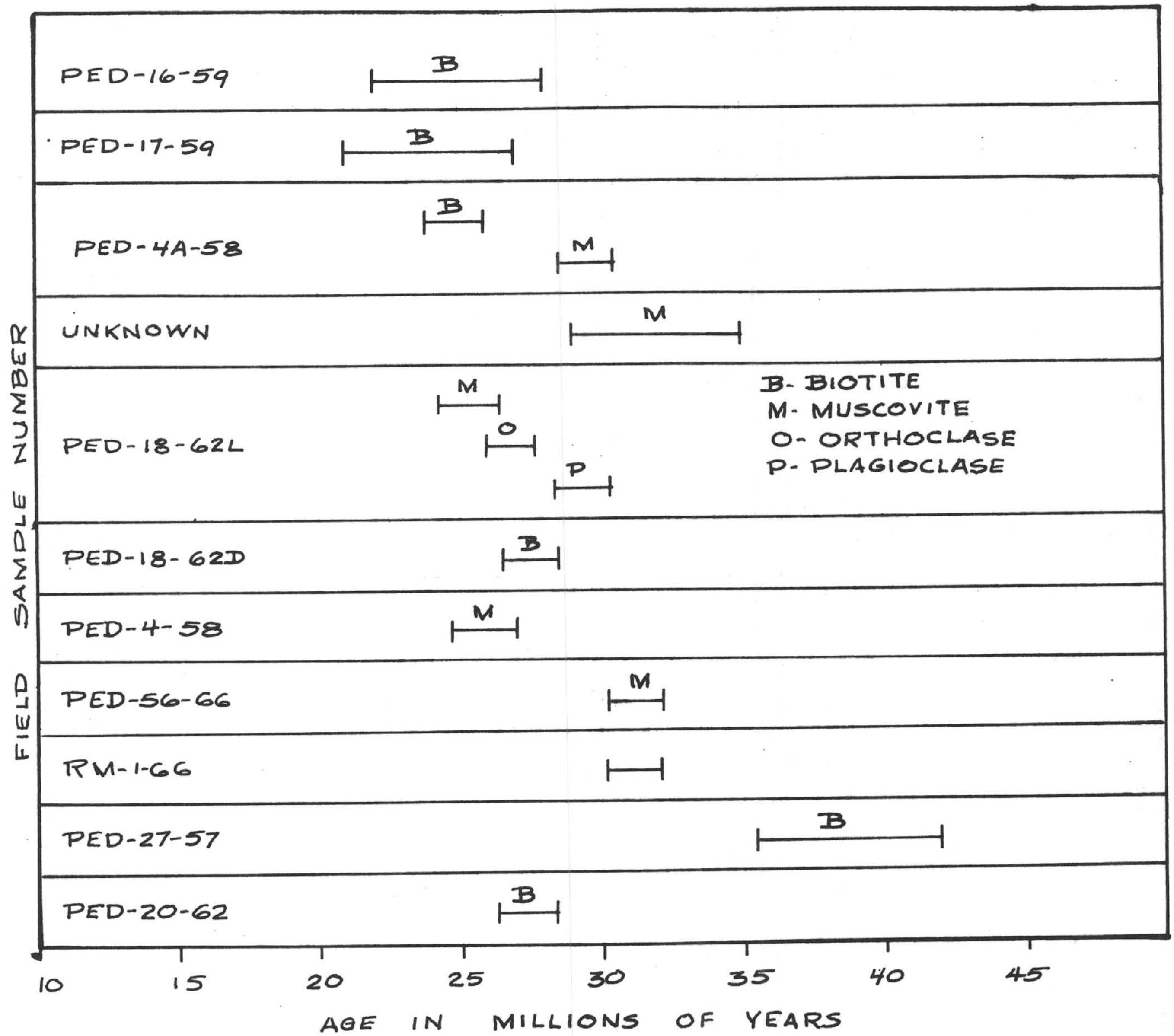


Figure 4.--Bar graphs of published K-Ar ages of quartz monzonite of Samaniego Ridge and gneissic rocks, Santa Catalina and Tortolita Mountains.

Table 3.--*Previously published Rb-Sr ages of the quartz monzonite of Samaniego Ridge, Oracle Granite, and gneissic rocks, Santa Catalina Mountains*

Location figure	Sample no.	Mineral dated	Apparent age m.y.	Rock type	Location	Reference
VI	---	Biotite	30. ±30	Quartz monzonite of Samaniego Ridge	500 ft from Pirate fault east of Canada Del Oro	Giletti and Damon, 1961; Damon and Giletti, 1961
II	---	Biotite muscovite mix	150. ±90	Gneissic rock	32°22.1' N. 110°43' W.	Giletti and Damon, 1961; Damon and Giletti, 1961
II	PED-4A-58	Biotite	23.9±14	Gneissic rock	32°22.1' N. 110°43' W.	Livingston and others, 1967
II	PED-4A-58	Muscovite	37.6± 1.0	Gneissic rock	32°22.1' N. 110°43' W.	Livingston and others, 1967
VI		Whole rock	90	Quartz monzonite of Samaniego Ridge[1]	---	Shakel and others, 1972
XI		Biotite	1450	Oracle Granite	32°33.5' N. 110°44' N.	Giletti and Damon, 1961; Damon and Giletti, 1961

[1]Called "Catalina granite" by Shakel.

EPILOGUE

Special mention of some of the ideas of B. N. Moore and C. F. Tolman, Jr., and their colleagues is merited because of their extensive and careful work. The short summary report (Moore and others, 1949) mentions the quartz monzonite of Samaniego Ridge (Santa Catalina granitic complex) only briefly, and it scarcely mentions the deformation responsible for the gneisses. It does indicate, however, that the pluton was of batholithic size; therefore, although this concept was available in 1949, it subsequently seems to have had little acceptance.

The following excerpts from B. N. Moore and others (unpub. data, 1938, 321 p.) clearly reveal that their concepts on the extent and origin of the batholith and on the relationships of deformation to the batholith differ little from ours. Their Late Cretaceous or early Tertiary age for the pluton was based on field relations with which we concur, and our middle Tertiary designation is based on radiometric ages obtained only recently.

> "For convenience the granites in the Tortollita (sic) Mountains, Mt. Lemmon, Youtcy Ranch, and Happy Valley are described separately in this report but they are considered parts of the Catalina batholith and on the map the symbol of the Catalina granite is applied to all these localities.
>
> "It may be suggested that the post-Cretaceous igneous rocks were intruded during a period of stresses which reached their peak in the intrusion of the granites of the Catalina batholith. Whether this zone can be traced east and west from this region and whether other regions of Tertiary thrusting show evidence of earlier deformation remains to be shown.
>
> "These intrusions are of great interest in the history of this region because they differ from those to the north and to the south. The alignment of the bodies and the presence of strong pressure effects in the formation of the gneisses suggest intrusion along a zone of deformation. The great amounts of solutions probably resulted from the effects of pressure in squeezing out solutions from partly consolidated magmas."

REFERENCES CITED

Banks, N. L., 1976, Reconnaissance geologic map of the Mount Lemmon quadrangle, Arizona: U.S. Geol. Survey Misc. Field Studies Map MF-747. (In press)

Calk, L. C., and Naeser, C. W., 1973, The thermal effect of a basalt intrusion of fission tracks in quartz monzonite: Jour. Geology, v. 81, p. 189-198.

Catanzaro, E. J., and Kulp, J. L., 1964, Discordant zircons from the Little Belt (Montana), Beartooth (Montana), and Santa Catalina (Arizona) Mountains: Geochim. et Cosmochim. Acta, v. 28, p. 87-124.

Creasey, S. C., and Theodore, T. G., 1975, Preliminary reconnaissance geologic map of the Bellota Ranch quadrangle, Pima County, Arizona: U.S. Geol. Survey Open-file Rept. 75-295.

Damon, P. E., Erickson, R. C., and Livingston, D. E., 1963, K-Ar dating of Basin and Range uplift Catalina Mountains, Arizona: Natl. Acad. Sci.--Natl. Research Council Pub. 1075, p. 113-121.

Damon, P. E., and Giletti, B. J., 1961, The age of the basement rocks of the Colorado Plateau and adjacent areas, in Geochronology of rock systems: New York Acad. Sci. Annals, v. 91, art. 2, p. 443-453.

Fleischer, R. L., Price, P. B., and Walker, R. M., 1965, Effects of temperature, pressure, and ionization on the formation and stability of fission tracks in minerals and glasses: Jour. Geophys. Research, v. 70, p. 1497-1502.

Giletti, B. J., and Damon, P. E., 1961, Rubidium-strontium ages of some basement rocks from Arizona and northwestern Mexico: Geol. Soc. America Bull., v. 72, no. 4, p. 639-643.

Livingston, D. E., Damon, P. E., Mauger, R. L., Bennett, Richmond, and Laughlin, A. W., 1967, Argon 40 in cogenetic feldspar-mica mineral assemblages: Jour. Geophys. Research, v. 72, no. 4, p. 1361-1375.

Mauger, R. L., Damon, P. E., and Livingston, D. E., 1968, Cenozoic argon ages from metamorphic rocks from the Basin and Range province: Am. Jour. Sci., v. 266, no. 7, p. 579-589.

Moore, B. N., Tolman, C. F., Jr., Butler, B. S., and Hernon, R. M., 1949, Geology of the Tucson quadrangle, Arizona: U.S. Geol. Survey open-file report, 20 p.

Naeser, C. W., 1976, Fission track dating: U.S. Geol. Survey Open-file Rept. 76-190.

Naeser, C. W., and Faul, H. O., 1969, Fission-track annealing in apatite and sphene: Jour. Geophys. Research, v. 74, no. 2, p. 705-710.

Peterson, N. P., 1938, Geology and ore deposits of the Mammoth mining camp area, Pinal County, Arizona: Arizona Bur. Mines Bull. 144, Geol. ser. 11, 63 p.

Shakel, D. W., 1974, The geology of layered gneisses in part of the Santa Catalina forerange, Pima County, Arizona: Arizona Univ., Tucson, M.S. thesis, 233 p.

Shakel, D. W., Livingston, D. E., and Pushkar, P. D., 1972, Geochronology of crystalline rocks in the Santa Catalina Mountains, near Tucson, Arizona: Geol. Soc. America, Abs. with Programs, v. 4, p. 408.

Shapiro, Leonard, 1975, Rapid analyses of silicates, carbonate, and phosphate rocks, revised ed.: U.S. Geol. Survey Bull. 1401, 76 p.

Table 4.--*Chemical, spectrographic, normative, and modal analyses of rocks from the Santa Catalina and Tortolita Mountains*

[Rapid rock analyses: analyst Hezekiah Smith, analytical method as described under "single solution" by Shapiro (1975). Analysis of Cl by R. Moore and B. McCall; spectrophotometric analytical method. Quantitative spectrographic analyses: analyst Chris Heropoulos. The results are reported to have significant figures and have an overall accuracy near the limit of detection where only one digit is intended]

	Massive quartz monzonite of Samaniego Ridge			Gneissic quartz monzonite of Samaniego Ridge	Quartz monzonite of Tortolita Mountains	Gneissic Oracle Granite
			Rapid rock analyses			
Lab. no.	M124370WD	M124371WD	M124372WD	M124757WD	M124374WD	M124373WD
Field no.	BR-16	BR-21	ML-61	GGN-S1	ML-105	ML-62R
SiO_2	73.2	68.6	67.0	74.1	73.2	70.0
Al_2O_3	13.6	15.3	15.5	15.1	14.4	15.4
Fe_2O_3	.89	1.3	2.0	.33	.72	1.6
FeO	.64	1.3	1.9	.52	.52	.92
MgO	.50	.90	1.7	.08	.24	.52
CaO	1.1	2.2	3.0	1.3	1.1	1.9
Na_2O	3.6	3.8	4.2	4.3	3.5	3.4
K_2O	4.6	4.6	3.8	3.9	5.0	4.8
H_2O+	.32	.79	.72	.49	.42	.74
H_2O-	.22	.19	.08	.05	.17	.26
TiO_2	.20	.38	.62	.01	.10	.34
P_2O_5	.11	.19	.28	.04	.07	.20
MnO	.03	.05	.09	.02	.02	.04
CO_2	.02	.01	.02	.02	.02	.01
Cl	.01	.01	.005	.01	.003	.005
F	.03	.01	.06	<.01	<.01	<.01
Sum	99+	100-	101-	100+	99+	100+
			Quantitative spectrographic analyses			
			Plate no. EM-1224			
Ti %	0.15	0.27	0.37	0.05	0.11	0.30
Mn (ppm)	370	470	800	260	250	330
Ba	330	1100	640	1500	1100	2400
Be	7	5	6	N1	2	N1
Co	N2	8	11	N2	N2	8
Cr	N2	8	12	N2	N2	N2
Cu	13	9	9	11	5	65
Ni	1.6	8	14	N1	1.5	2
Sc	N1.5	7	8	N1.5	N1.5	7
Sr	170	350	380	220	180	650
V	23	44	72	N3	16	39
Y	10	19	26	N10	10	26
Zr	48	36	110	31	82	50
Ga	18	18	21	12	16	17
Yb	1	1	2	N1	1	1

N = not detected at value shown.

			Norms			
Quartz	32.2	23.2	19.5	31.0	31.4	27.6
corundum	1.0	.6	---	1.6	1.5	1.7
orthoclase	27.5	27.3	22.3	23.0	29.8	28.4
albite	30.8	32.3	35.2	36.3	29.8	28.8
anorthite	4.7	9.7	12.1	6.0	4.9	8.1
wollastonite	---	---	.3	---	---	---
enstatite	1.3	2.3	4.2	.2	.6	1.3
ferrosilite	.2	.8	1.0	.7	.2	---
forsterite	---	---	---	---	---	---
fayalite	---	---	---	---	---	---
magnetite	1.3	1.9	2.9	.5	1.1	2.1
ilmenite	.4	.7	1.2	tr	.2	.6
apatite	.3	.5	.7	.1	.2	.5

			Modes			
quartz	33.0	16.3	30.4	33.2	39.2	Not determined.
K-spar and perthite	38.3	30.5	24.1	22.8	31.2	
plagioclase	24.4	41.0	37.7	35.8	26.4	
biotite	2.9	9.1	6.1	3.8	3.2	
hornblende	---	1.4	.3	---	---	
magnetite	.9	1.0	.5	.2	tr	
sphene	.3	.3	.6	tr	---	
apatite	.2	.4	.3	tr	tr	
zircon	tr	tr	tr	tr	tr	
muscovite	---	---	---	4.2	---	
garnet	---	---	---	tr	---	
Sum	100	100	100	100	100	
An-content of plagioclase	An_{20}?	An_{20}	An_{20}	An_{20}	An_{20}	An_{20}?

Analytical data for fission-track ages for Santa Catalina and Tortolita Mountains

[Methods for fission-track age determinations are similar to those currently employed by C. W. Naeser (Naeser, 1976); $\lambda_F = 6.85 \times 10^{-17}$ yr^{-1}. Numbers of tracks counted are given in parentheses. The ± figures for estimated analytical uncertainty are based on numbers of tracks counted for ρs, ρi, and φ determinations]

Sample	Mineral	$\rho s \times 10^6$, tracks/cm^2	$\rho i \times 10^6$, tracks/cm^2	$\phi \times 10^{15}$, neutrons/cm^2	Age ± 2σ $\times 10^6$ years
ML-61	Apatite	0.323 (1220)	3.50 (1487)	3.59	20.2±2.1
ML-61	Zircon	3.29 (625)	14.9 (1330)	1.83	26.3±3.4
ML-61	Sphene	1.15 (1014)	4.74 (2087)	1.85	27.5±3.1
BR-21	Apatite	0.204 (773)	1.97 (835)	3.59	22.8±2.8
BR-21	Zircon	5.18 (797)	18.1 (1396)	1.61	28.1±3.3
BR-21	Sphene	2.79 (1308)	9.54 (2238)	1.63	29.1±3.0
ML-60	Apatite	.201 (761)	2.13 (905)	3.59	20.7±2.5
ML-60	Sphene	.918 (551)	3.76 (1129)	1.87	27.9±3.7
BR-16	Apatite	.305 (1152)	3.38 (1434)	3.59	19.8±2.1
BR-16	Zircon	4.98 (1436)	19.7 (2841)	1.62	25.1±1.5
BR-16	Sphene	1.39 (912)	5.15 (1691)	1.65	27.2±3.1
Ggn-S1	Apatite	.0393 (297)	.462 (1749)	3.59	18.7±2.7
RC-25	Apatite	.113 (429)	1.23 (2066)	3.19	18.0±2.4
ML-105	Apatite	.163 (617)	2.17 (921)	3.59	16.5±2.1

Analytical data for K-Ar ages for the Santa Catalina and Tortolita Mountains

Sample	Mineral	Percent	K_2O	$*Ar^{40}$moles/gm	$*Ar^{40}/\Sigma Ar^{40}$	Age, 10^6 yrs.
GGN-S1	Biotite	8.79	8.78	2.96482×10^{-10}	62.2%	22.7±0.7
GGN-S1	Muscovite	9.78	9.75	3.50169×10^{-10}	74.6	24.1±0.7
ML-61	Biotite	8.59	8.62	3.07432×10^{-11}	78.6	24.0±0.7
ML-61	Hornblende	.927	.924	3.07276×10^{-10}	38.6	22.3±0.7
ML-60	Biotite	9.10	9.10	3.18397×10^{-10}	78.4	23.5±0.7
ML-60	Hornblende	1.042	1.040	5.70900×10^{-11}	53.0	36.8±1.0
BR-21	Biotite	7.28	7.32	2.50623×10^{-10}	63.8	23.1±0.7
BR-21	Hornblende	.598	.598	2.07901×10^{-11}	20.4	23.4±1.2
BR-16	Biotite	9.10	9.10	3.13143×10^{-10}	67.3	23.2±0.2
RC3-1	Biotite	8.64	8.63	2.64175×10^{-10}	52.5	20.6±0.6
RC3-1	Hornblende	.933	.934	2.92466×10^{-11}	49.9	21.1±0.6
RC-25	Biotite	8.33	8.40	2.74315×10^{-10}	69.1	22.1±0.7

$\lambda_{\varepsilon} = 0.585 \times 10^{-10}$/yr.

$\lambda_{\beta} = 4.72 \times 10^{-10}$/yr.

$K^{40}/K_{total} = 1.19 \times 10^{-4}$ mole/mole

AREA

No. Santa Rita Mountains

NAME

1. LESSOR

Felix Ruelas

3. CONSIDERATION ________

CHECK NO. ________

4. ACREAGE 400 ±

INTEREST ________

5. LEASE TERMS

Primary Term ______ Years. Royalty ________

Consideration Paid For Period Of ________

Rental ______ /ac./ ________ , Payable ________

2. MINERAL RESERVATION ☐ FEE ☒

Surface Owner ________

6. TITLE INFORMATION

Title Co. ☐ Assessors ☒ Collectors ☐

Bur. of Ld. Mgmt.

Inst. No.	Date	Rec'd.	Bk-Pg

7. ADDRESS

8. T.I. ARB. NO.

9. COUNTY Pima

Property Description

Section 10: NW^4; NE^4; N^2SE^4

The U.S. Government retains the mineral rights on Section 10: N^2SE^4

Sec. 10 Twp. 18S Rge. 15E s.b.b. & m. / m.d.b. & m.

WORK SHEET NO. ________

FORM 366LA6

10. FOR LEASEMEN ONLY

Have all riders, additions & / or deletions to lease initialed by ALL PARTIES to the lease. Show marital status. If married man, wife must sign also. If married woman, have husband sign also if possible.

A. DIRECTIONS ____________________

B. BANK AND LOCATION ____________________

C. REMARKS (Recent Transfers, Mineral Reservations, Trust Deeds Etc.): ____________________

D. FLASH REPORT ☐ E. WEEKLY LEASE REPORT ☐

11. INSTRUCTIONS FOR RE-WRITES OF LEASE &/OR CHECK, RIDERS, DELETIONS TO LEASE Etc.

AREA
No. Santa Rita Mountains

NAME

1. LESSOR
Osar Buckelew

3. CONSIDERATION ______
CHECK NO. ______

4. ACREAGE 160 ±
INTEREST ______

5. LEASE TERMS
Primary Term ______ Years. Royalty ______
Consideration Paid For Period Of ______
Rental ______ /ac./ ______ , Payable ______

2. MINERAL RESERVATION ☐ FEE ☒
Surface Owner ______

6. TITLE INFORMATION
Title Co. ☐ Assessors ☒ Collectors ☐
Bureau of Ld. Mgmt.

Inst. No.	Date	Rec'd.	Bk-Pg

7. ADDRESS

8. T.I. ARB. NO.

9. COUNTY Pima
Property Description

Section 10: S^2SE^4

Section 15: N^2NE^4

Sec. ______ Twp. 18 S Rge. 15 E s.b.b. & m. / m.d.b. & m.

WORK SHEET NO. ______

FORM 366LA6

10. <u>FOR LEASEMEN ONLY</u>

Have all riders, additions & / or deletions to lease initialed by ALL PARTIES to the lease. Show marital status. If married man, wife must sign also. If married woman, have husband sign also if possible.

A. DIRECTIONS ____

____

____

B. BANK AND LOCATION

____

____

C. REMARKS (Recent Transfers, Mineral Reservations, Trust Deeds Etc.): ______________

____

____

____

____

D. FLASH REPORT ☐ E. WEEKLY LEASE REPORT ☐

11. INSTRUCTIONS FOR RE-WRITES OF LEASE &/OR CHECK, RIDERS, DELETIONS TO LEASE Etc.

Structural Geology of the Sierrita Mountains,

Pima County, Arizona

by

Harald Drewes

U.S. Geological Survey, Denver, Colo. 80225

(Abstract of talk to be given at AIME symposium on Sierrita Mts., April 13, 1973)

The Sierrita Mountains, some 25 miles southwest of Tucson, Ariz., are almost as well known for their complex structures as for their tremendous deposits of copper. Although the area near the mines has been studied in detail, range-wide structural interpretations have been few or have been little publicized, in part because of the difficulty in piecing together many small structurally complex areas that are separated from each other by large stocks or extensive deposits of pediment gravel, and in dating and correlating metamorphosed rocks. The interpretation here offered is based on the detailed map of the Twin Buttes quadrangle by John R. Cooper, augmented by my own detailed work in the Rincon and Santa Rita Mountains and reconnaissance mapping extending from the west flank of the Sierrita Mountains to the borders of Sonora and New Mexico. As a preliminary model of the structural development of a complex range, the interpretation is offered with the expectation that it will be substantially modified as the efforts to find more ore deposits continue.

The Sierrita Mountains contain many faults, both low-angle and high angle, and folds, all of which are now interrupted by large stocks. Most of the strong deformation occurred during the Laramide Orogeny, of Late Cretaceous to Paleocene age (about 90-53 m.y. (million years) ago).

Evidence for pre-Laramide deformation is scanty because it is much obscured by later deformation, whereas evidence for post-Laramide deformation is both widespread and relatively clear.

The sparse record of pre-Laramide rocks and structures in the Sierrita Mountains suggests a sequence of events much like that proposed for the Santa Rita Mountains. During the Precambrian, Pinal Schist was foliated, folded, and intruded by bodies of porphyritic granodiorite which are themselves weakly foliated. In Paleozoic time the sea invaded the area and deposited rocks in a miogeosynclinal environment. During the Triassic through Lower Cretaceous, continental conditions prevailed; from time to time magmatic activity and local relief increased markedly, but the occurrence of faulting during the interval is inferred primarily from the local record of sedimentation and from the structural record in nearby mountains.

During the Laramide Orogeny, the rocks of the area were intruded several times, were strongly compressed and thrust faulted, and were widely metamorphosed and locally mineralized. During this involved period of structural development of the Sierrita Mountains the following major events occurred:

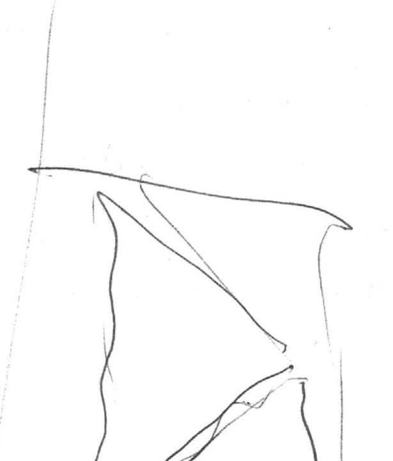
(1) Thrust plates of regional scale were pushed east-northeastward on the Sierrita thrust fault between the times of deposition of the Demetrie Volcanics (upper Upper Cretaceous; ~75 m.y.) and the Red Boy Rhyolite (upper Upper Cretaceous; 72-73 m.y.). Some rocks of the thrust plate were folded, cut by strike-slip faults, thinned, and possibly tectonically metamorphosed. Thrust faults in the Sierrita Mountains, particularly the ones on the west side of the mountains,

resemble those in the northernmost Santa Rita Mountains and in the Rincon Mountains in that several major plates of Paleozoic and Mesozoic rocks and substantial sheets of Precambrian rocks are involved. If the thrust plates in these three mountain ranges are related, then the postulated amount of tectonic transport as suggested by evidence in the Rincons may exceed 10 or perhaps even 20 miles.

(2) Large stocks of Ruby Star Granodiorite were emplaced about 59 m.y. ago, apparently under the influence of northwest-trending pre-Laramide structural grain, also present in some nearby ranges. The widespread thermal metamorphism of the area is probably associated with this magmatic event.

(3) Scattered small stocks of quartz latite porphyry or fine-grained quartz monzonite porphyry (ore porphyry) were intruded about 55 m.y. ago along the east flank of the Sierrita Mountains. Ore fluids, which apparently were associated with or immediately followed this magmatic event, spread along faults and the margins of plutons. From these fluids, metals were deposited in various favorable host rocks close to both the ore porphyry and the available conduits.

Post-Laramide structural features include local high-angle faults and a shallow low-angle fault, as well as some small intrusive bodies. High-angle faulting occurred during several intervals, but in general is datable only as pre-late Oligocene and post-late Oligocene. Some of these faults utilized older high-angle structures, and probably some faulting is associated with the development of high local relief southeast of the Sierrita Mountains. A plate of rock, perhaps only a few thousand feet thick and a few tens of square miles in extent, is postulated by Cooper to have moved about 7 miles northward from the high area down a gentle gradient on the dish-shaped San Xavier fault. Rocks of this glide plate include some previously thrust-faulted Cretaceous and older rocks, as well as fanglomerate containing intercalated wedges of monolithologic breccia, of landslide origin, and flows of andesite dated at 31 m.y. Rhyodacite dikes 24 m.y. old appear to postdate the gravity gliding and are penecontemporaneous with the youngest volcanic rocks occurring on the flanks of the Sierrita Mountains. The postulated area of high local relief must have been faulted down during the late Tertiary to initiate the basin now occupied by the Santa Cruz River.



20