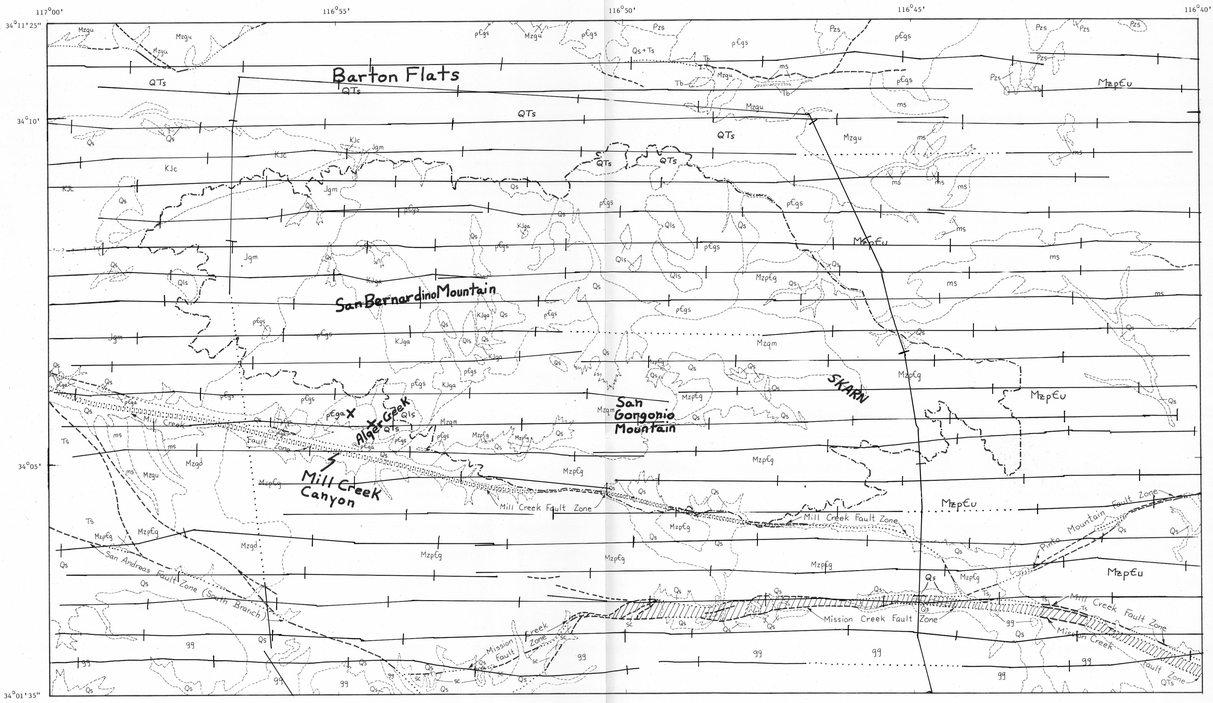
DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY

MISCELLANEOUS FIELD STUDIES
MAP MF-1161-B
PLATE 1 OF 2



Base from U.S. Geological Survey
San Gorgonio Mountain, 1954; Morongo Valley, 1955

SCALE 1:62 500

1 ½ 0 1 2 3 4 MILES

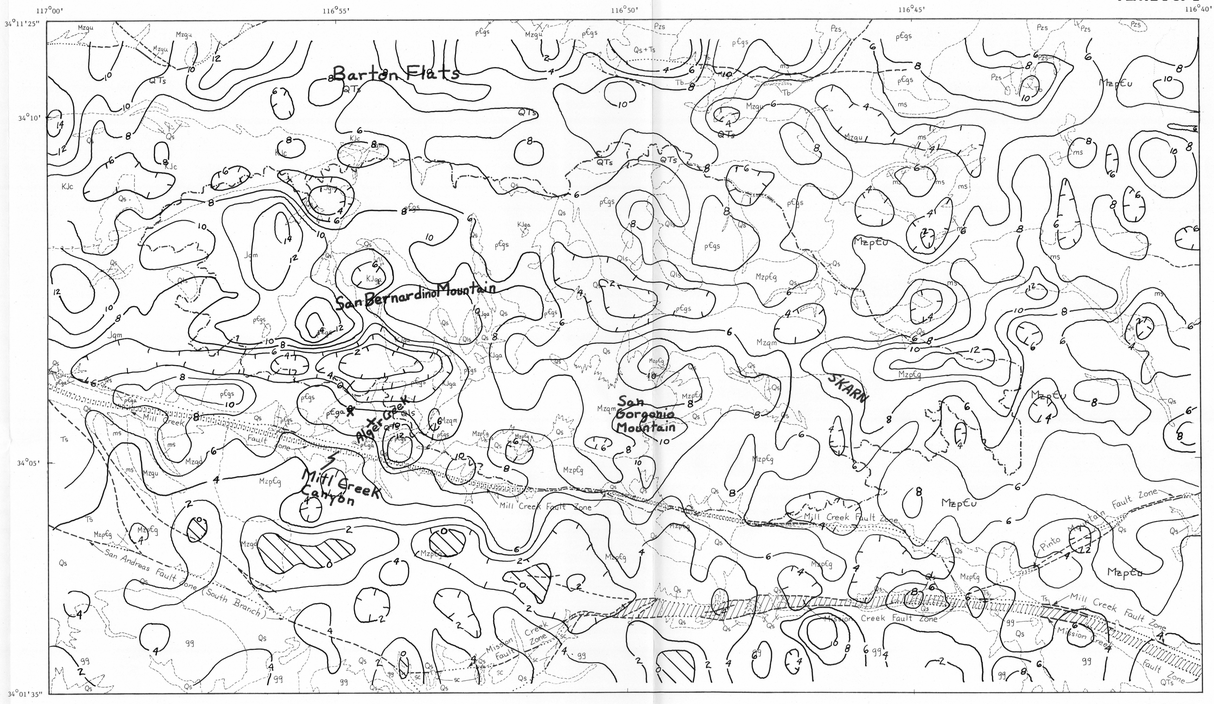
1 .5 0 1 2 3 4 KILOMETERS

Geology by D. M. Morton, B. F. Cox, and J. C. Matti. Area outside Wilderness Area by T. W. Dibblee, Jr., modified by Morton, Cox, and Matti

EXPLANATION

FLIGHT LINE--Dotted where data lost due to equipment failure; tick marks along flight lines indicate time intervals of 1 min

Map A.--Locations of flight lines of aerial radiometric survey



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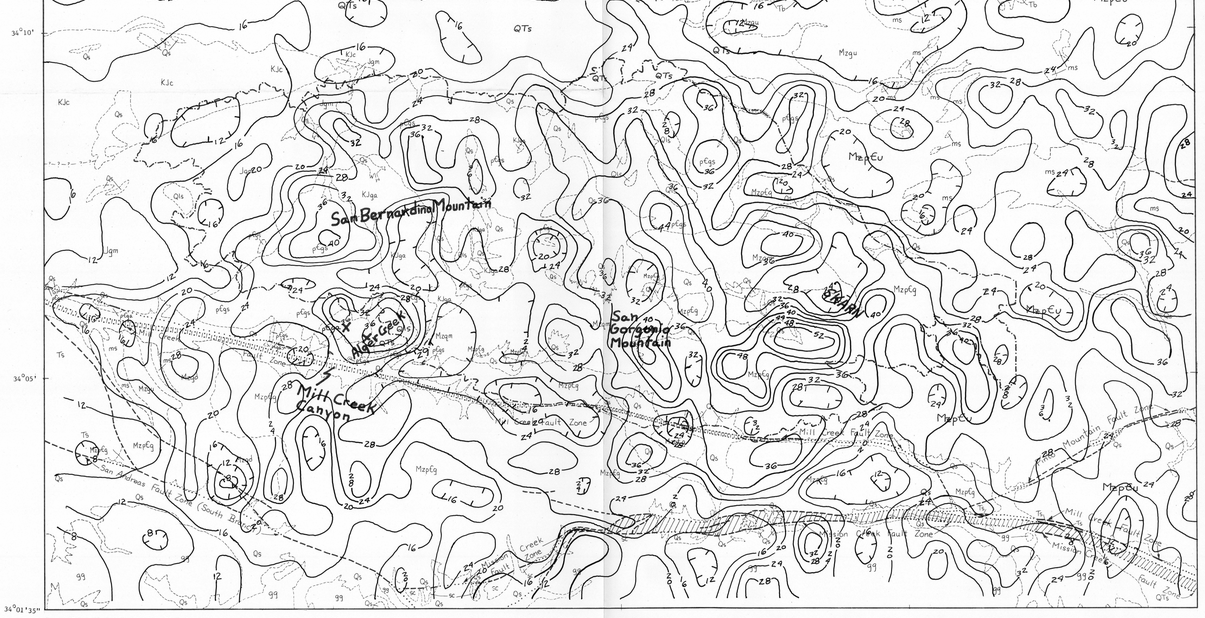
Geology by D. M. Morton, B. F. Cox, and J. C. Matti. Area outside Wilderness Area by T. W. Dibblee, Jr., modified by Morton, Cox, and Matti

EXPLANATION

eU CONTOUR--Contour interval, 2 ppm eU. Hachures indicate closed area of lower concentration

AREA WHERE CALCULATED CONCENTRATIONS ARE NEGATIVE

Map B.--Map of the apparent surface concentration of eU



Base from U.S. Geological Survey
San Gorgonio Mountain, 1954; Morongo Valley, 1955

SCALE 1:62 500

1 ½ 0 1 2 3 4 MILES

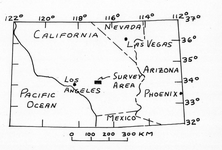
1 .5 0 1 2 3 4 KILOMETERS

Geology by D. M. Morton, B. F. Cox, and J. C. Matti. Area outside Wilderness Area by T. W. Dibblee, Jr., modified by Morton, Cox, and Matti

EXPLANATION

eTh CONTOUR--Contour interval, 4 ppm. Hachures indicate closed area of lower concentration

Map C.--Map of the apparent surface concentration of eTh



Index showing location of San Gorgonio Survey Area

LIST OF MAP UNITS

Qs	SURFICIAL MATERIALS--Including alluvium, colluvium, glacial, and landslide material
Qls	LANDSLIDE DEPOSITS
QTs	SURFICIAL MATERIALS (QUATERNARY) AND SEDIMENTARY ROCKS OF VARIOUS AGES AND VARYING LITHOLOGIES (TERTIARY)
Ts	SEDIMENTARY ROCKS OF VARIOUS AGES AND VARYING LITHOLOGIES
Tb	BASALT
KJga	GRANODIORITE OF ANDERSON PEAK
KJgc	QUARTZ DIORITE OF CAMP ANGELUS
Jgm	GRANODIORITE OF MANZANITA SPRINGS
Mzgu	UNDIFFERENTIATED GRANITIC ROCKS
Mzgd	GRANODIORITE OF YUCAIPA RIDGE
Mzqm	QUARTZ MONZONITE OF SAN GORGONIO MOUNTAIN
Mzpeu	UNDIVIDED METAMORPHIC AND IGNEOUS ROCKS--Includes granitic rocks (Mzgu), heterogeneous gneissic granitoid rocks (Mzpeg), and biotite gneiss and schist (pEgs)
Mzpeg	UNDIVIDED HETEROGENEOUS GNEISSIC GRANITOID ROCKS
Pzs	QUARTZITE, PHYLLITE, AND LIMESTONE, MARBLE
pEga	ORTHOGNEISS OF ALGER CREEK
pEgs	BIOTITE GNEISS AND SCHIST
sc	GREENSTONE, SCHIST, AND METACHERT--Rock types lithologically correlative with the Paleocene and older Pelona Schist
gs	GRANITIC AND GNEISSIC ROCKS--Probably includes Mesozoic and Precambrian rocks
ms	METAQUARTZITE, MARBLE, SCHIST, AND AMPHIBOLITE OF UNCERTAIN AGE AND LITHOLOGIC CORRELATION

CONTACT--Queried where inferred

FAULT--Dotted where concealed

MILL CREEK FAULT ZONE

MISSION CREEK FAULT ZONE

ALGER CREEK URANIUM LOCALITY

BOUNDARY OF SAN GORGONIO WILDERNESS AREA

Mission Creek fault named by Allen (1957) and has been extended into San Bernardino Mountains by Ehlig (1977) and by Matti, Cox, and Morton (unpublished mapping). Mill Creek fault named by Allen (1957) and is used in this report rather than "north branch, San Andreas Fault" of Dibblee (1964, 1967, 1968).

Studies Related to Wilderness

The Wilderness Act (Public Law 88-577, Sept. 3, 1964) and related Acts require the U.S. Geological Survey and the U.S. Bureau of Mines to survey certain areas on Federal lands to determine their mineral resource potential. Results must be made available to the public and be submitted to the Administration and the Congress. This report presents the results of an aerial radiometric survey of the San Gorgonio Wilderness Area.

CORRELATION OF MAP UNITS

QTs	Qs Qls	QUATERNARY	CENOZOIC
Ts	Tb	TERTIARY	
UNCONFORMITY			
Mzgu Mzgd	Kzgs Kzgc	CRETACEOUS OR JURASSIC	MESOZOIC
	Jgm	JURASSIC	
UNCONFORMITY			
Mzpeu Mzpeg	Mzqm		MESOZOIC(?)
UNCONFORMITY			
	Pzs		PALEOZOIC(?)
	pCgs pEgs pEga		PRECAMBRIAN
	sc gs ms		AGE UNCERTAIN

SUMMARY STATEMENT

The aerial radiometric data for the San Gorgonio Wilderness Area show slight correlation with mapped geology and contain no information of economic significance. Precambrian and modified Precambrian crystalline rocks have more eTh compared to Mesozoic plutonic rocks and one rock unit mapped as a pluton has slightly more K. These rocks have essentially uniform ratios of eU/eTh and eU/K despite their different origins. The ratios also show that part of the granodiorite of Manzanita Springs could be somewhat deficient in eTh and K. It is concluded that the mapped radiolement distributions are within reasonable limits for the rock types involved, and there is no immediate evidence on any anomalous concentrations of radioactive minerals within the Wilderness Area.

INTRODUCTION

An aerial radiometric and magnetic survey of the San Gorgonio Wilderness Area and vicinity (index) was made during October and November, 1976. The survey area lies in southern San Bernardino County, north of San Gorgonio pass. This report presents the radiometric data obtained by the survey and an interpretation of the data. The magnetic data are being compiled by H. W. Oliver, J. C. Matti, J. A. Pitkin, and J. S. Duval (written commun., 1981).

METHOD

An aerial radiometric survey measures gamma radiation from materials at the Earth's surface. Most of the gamma rays originate from potassium (K-40), and from the decay products of the radioelements uranium-238 (U-238) and thorium-232 (Th-232). The distribution of these elements and their decay products is controlled by the complex interaction of geological and geochemical processes, such as hydrothermal fluid movement, groundwater flow, weathering, erosion, and transportation. In addition, this distribution can vary greatly from one rock type to another, for example granitic (high concentration) and limestone (low concentration). Because of the relationship to geological processes and to rock type, measurements of radioelement distribution can be used to aid geologic mapping and in mineral exploration.

Scintillation detectors are typically used for aerial gamma-ray surveys. The detectors with their associated electronic equipment are mounted in aircraft that should follow the contour of the ground with a clearance of no more than 700 ft (213 m). The low ground clearance is necessary for statistically valid measurements because gamma rays are absorbed at an exponential rate as the thickness of the air beneath the aircraft increases. Because the gamma rays are also absorbed exponentially by the surface materials, the measurements only detect the radioelement concentrations in the uppermost 1.5 ft (0.5 m) of rock and soil.

EQUIPMENT

The equipment used for this survey is a four-channel gamma-ray spectrometer that its associated electronics, a large volume (6912 cubic inches) (113.3 liter) plastic (polyvinyl toluene) detector (Duval and Pitkin, 1978), a proton-precession magnetometer, a radar altimeter, a digital magnetic tape recorder, an analog strip-chart recorder, and a 35-mm flight line tracking camera. The spectrometer was calibrated to measure gamma rays from the U-238 and Th-232 decay series and K-40. Data from the spectrometer, magnetometer, radar altimeter, and a digital clock were measured at one-second time intervals and recorded on magnetic tape. The 35-mm camera photographed the flight path of the aircraft at two-second intervals. All equipment were mounted in a single-engine Pilatus Porter STOL aircraft.[1]

SURVEY PARAMETERS

The data were measured at a nominal ground clearance of 400 ft (122 m) and a speed of about 100 mi/hr (160 km/hr). At this height above ground level the effective ground area measured by the spectrometer is a strip along the flight line about 800 ft (224 m) wide. Twenty-one flight lines, 18.6-19.2 mi (30-31 km) long, were flown east-west at intervals of 0.5 mi (0.8 km). To maintain 400 ft (122 m) above ground level, all flight lines were flown in level and (or) downhill sections because topographic relief in the area approaches 8200 ft (2500 m). The flight lines are shown on map A.

[1] Any use of trade names is for descriptive purposes only and does not imply endorsement by the USGS.

DATA REDUCTION

The data were processed to obtain contour maps of the apparent surface concentrations of potassium (K), uranium (eU), thorium (eTh), the ratios eU/eTh, eU/K, eTh/K (maps A through G, respectively). The e (for equivalent) prefix is used as a reminder that the measurement is not direct; disequilibrium between parent and measured daughter product can occur in the U- and Th-decay series.

Corrections applied to the radiometric data include background subtraction to remove counts due to cosmic rays and aircraft contamination and normalization to the nominal survey altitude (400 ft; 122 m) to remove variations caused by changes in the ground clearance. The corrected radiometric data were converted to apparent surface concentrations of the radioelements by using equations based upon calibration data obtained at the calibration pads established by the U.S. Department of Energy at Walker Field Airport, Grand Junction, Colorado. For some areas of the contour maps, negative radioelement concentrations resulted from the calculations. The negative numbers are caused by a combination of actual low concentrations coupled with statistical fluctuations in the measured count rates and errors inherent in the calibration equations.

GEOLOGY

The geologic map of the San Gorgonio Wilderness Study Area (with additional data from Morton, Cox, and Matti, 1980, and Dibblee, 1964; 1967) was compiled at a scale of 1:62,500 and is the base for the radiometric data (maps B-G). Most of the geologic data in the succeeding discussion are from Matti, Cox, and Morton (oral and written communications, 1980-81), with additional information from Allen (1957) and Dibblee (1964, 1967). As a number of units on the generalized map do not have formal names, their map symbols are frequently used to facilitate the discussion.

Bedrock in the San Gorgonio study area is a heterogeneous mixture of crystalline rocks of probable Precambrian and Mesozoic age. Paleozoic metasedimentary and Cenozoic sedimentary and extrusive igneous rocks partially mantle the crystalline rocks, and several strands of the San Andreas fault zone cross the southern part of the study area. Gneiss and schist of Precambrian age were partially melted and were intruded by igneous rocks of granitic to quartz dioritic composition during Mesozoic time. This mixing of rock types resulted in heterogeneous compositions and the composite unit (Mzpeg) shown on the geologic map. Within the Wilderness Area, bedrock is gneiss and schist (pEgs) of Precambrian age, heterogeneous gneissic granitoid rocks (Mzpeg) of several ages, granodiorite (Jgm, KJc, KJga) of Mesozoic age, and a unit mapped as quartz monzonite (Mzqm) of Mesozoic age. Throughout the survey area, bedrock is often mantled by alluvium, colluvium, landslide debris, and glacial material (Qs, Qls) of Quaternary age.

Uranium and thorium mineralization is known to occur in the canyon of Alger Creek, about 1.25 mi (2 km) southeast of San Bernardino Mountain, south of the Wilderness Area boundary, and north of Mill Creek Canyon. Allanite, uranothorite, zircon, magnetite, and biotite occur in a matrix of feldspathic rock, mostly microcline. The country rock is the orthogneiss of Alger Creek (pEga), and uranium ore (<10 tons, >4500 kilograms) of unknown grade was shipped from one Alger Creek locality in the early 1950's (Hewett and Stone, 1957). All mapped occurrences of the country rock are outside of the Wilderness Area, along the north side of Mill Creek Canyon.

Bodies of skarn or mineralized marble crop out on the east ridge of San Gorgonio Mountain, within the contact zone between the quartz monzonite of San Gorgonio Mountain (Mzqm) and the heterogeneous gneissic granitoid unit (Mzpeg) (Shay, 1975). Skarn is often associated with iron ore and sulfide mineralization, but this association is not seen in the San Gorgonio Mountain occurrence.

Paleozoic limestone (Pzs) in San Bernardino County can contain base- and precious-metal mineralization where intruded by granitic rocks (Wright and others, 1953, p. 69, 79, 151, 152). This type of rock does not occur in the Wilderness Area, occurs only sparsely in the survey area, and such mineralization is not known.

INTERPRETATION OF RADIOMETRIC DATA

The radiometric data in this report are presented as radioelement and radioelement-ratio contour maps. These data initially are interpreted by comparison with mapped geology. Where correspondence exists, the geologic reason for the correspondence is used to try to explain areas where correspondence is nebulous or does not exist. For these instances, interpretation depends upon some understanding of the surface geochemistry that the radiometric data reflect that is not derived from the mapped geology. Radioelement contour maps provide direct information on the relative abundance of an element in the form of concentration values (ppm and percent). These values are not absolute and should be considered as apparent or relative values. Ratioing of the radioelements highlights subtle changes in the relative concentrations that can have geochemical significance.

eU (map B)

Within the San Gorgonio Wilderness Area, anomalous values of eU were not observed and little correlation exists between eU values or contour patterns and the mapped geology. The Mesozoic intrusive rocks (Kjga, Jgm) and a unit similar in composition (Mzqm) were considered as one unit for interpretation, and the Precambrian (pEgs) and modified Precambrian (MzpEg) rocks were grouped together as a second unit. In general, the eU values of these two units show similar ranges in variability. Values in the Mesozoic rocks range from 4 to 14 ppm, whereas values in the Precambrian rocks range from 2 to 14 ppm.

The eU data show relatively low values (0-6 ppm) for the area south of the Mill Creek fault zone. North of the fault, including the Wilderness Area, eU is relatively higher in gross aspect but is variable from 2 to 14 ppm. Throughout the survey area, no discernible correlation exists for relatively higher (>10 ppm) or lower (<10 ppm) eU with specific rock type(s). The mineralization at Alger Creek is not anomalous as relative values are of only moderate level (8-10 ppm).

eTh (map C)

Within the Wilderness Area, correlation appears to exist between eTh values and rock type. A large area of relatively higher values includes part of San Bernardino Mountain, extends east-northeast in an arcuate manner to San Gorgonio Mountain, and then extends east and east-southeast about 5 mi (8 km). This zone has eTh values ranging between 28 and 52 ppm. Rocks within the zone include Precambrian gneiss and schist together with melted and reorganized gneissic granitoid rocks (Mzpeg), and zones of igneous-appearing rock that represent highly melted and reorganized Precambrian rock (Mzqm). The latter unit (Mzqm) is referred to as quartz monzonite of San Gorgonio Mountain (J. C. Matti, oral communication, 1980). All of these rocks either are Precambrian in age, or are modified, melted, and rearranged rocks produced during Mesozoic thermal events (J. C. Matti, written communication, 1981). By contrast, discrete, sharply bounded plutons of confirmed Mesozoic age (Kjga, Kjgc, Jgm) located mainly in the west end of the Wilderness Area display relatively lower eTh values (12-32 ppm).

That part of the survey area south of the Mill Creek fault zone is generally low in eTh (<24 ppm), but it is not as distinct as the feature on map B (for eU). The Alger Creek uranium mineralization is associated with relatively higher eTh of as much as 40 ppm.

K (map D)

The K data within the Wilderness Area range from 0.6 to 2.6 percent and show slight correlation with mapped geologic units. The quartz monzonite of San Gorgonio Mountain (Mzqm) is mostly 1.4-2.6 percent K, but areas with similar values occur within the Precambrian (pEgs) and modified Precambrian (Mzpeg) rocks.

Outside of the Wilderness Area, the area south of the Mill Creek fault zone has a pattern of low to moderate K concentrations (<1.0 to >1.8 percent). This area is a relative low on all three radioelement maps (maps B, C, and D). The mineralization at Alger Creek correlates with a localized, relative high of more than 1.8 percent K.

eU/eTh (map E)

These data are quite uniform (>0.1 to >0.4) for most of the study area, not reflecting the detail of the element maps (maps B and C). This phenomenon probably indicates that the eU/eTh ratio is similar for all rock types involved, despite different origins. The major exception to the uniform ratio is in the northeast corner of the study area, partly within the Wilderness Area. Here higher ratios of 0.4->0.8 are primarily for the granodiorite of Manzanita Springs (Jgm) and are explained by relatively lower eTh (map C). The remainder of the Wilderness Area has uniform values similar to most of the survey area outside of the Wilderness Area. The area south of the Mill Creek fault zone has ratios of <0.1->0.5, reflecting low eU.

eU/K (map F)

The eU/K data have a gross aspect similar to that of the eU/eTh data (map E), as most of the survey area has uniform values (2-4). Again, these data probably indicate a similar eU/K ratio for the rock types involved, and the major exception is in the northwest part of the survey area, partly within the Wilderness Area. Here the area of the higher ratio is mostly confined to the granodiorite of Manzanita Springs where the higher values are explained by relatively less abundant K (map D). The remainder of the Wilderness Area has uniform values similar to most of the survey area outside of the Wilderness Area. The area south of the Mill Creek fault zone has ratios of <0.1->0.5 that again reflect low eU (map B).

eTh/K (map G)

The eTh/K data register higher values (>20) in the form of a roughly circular high in the approximate center of the study area. This high includes most of the Wilderness Area, is generally associated with Precambrian gneiss and schist (pEgs) and modified Precambrian (Mzpeg) rocks, and is thought to reflect relatively more abundant eTh (map C) rather than deficient K (map D). The high is broken by a belt of lower values (10-20) that coincides with the rock unit referred to as quartz monzonite of San Gorgonio Mountain, and results from relatively more abundant K (map D). West of the Wilderness Area two small highs (>20) are in Jurassic granodiorite of Manzanita Springs and Cretaceous and Jurassic quartz diorite of Camp Angelus, approximately coincide with highs in the other ratios (maps E and F), and could result from more abundant eTh (map C).

SUMMARY OF RADIOMETRIC INTERPRETATION

The radiometric data show little correlation with mapped geology. The maps contain distinctive contour patterns that seldom coincide with geologic contacts. A lithologic association of Precambrian and modified Precambrian rocks with relatively higher eTh occurs mostly within the Wilderness Area. Mesozoic plutonic rocks have comparatively less eTh and one of them, the quartz monzonite of San Gorgonio Mountain, has slightly higher K, probably due to more abundant K feldspar. The changes in eTh concentration likely relate to variations in accessory minerals (allanite, thorite, monazite, zircon) concentrations. Slight variation in the ratios eU/eTh and eU/K for most of the Wilderness Area indicates a uniformity of these ratios and the associated mineralogy for the rock types involved, despite different origins. At the west end of the Wilderness Area, the ratios show that part of the granodiorite of Manzanita Springs probably is deficient in eTh and K. The eTh/K ratio corroborates the higher eTh of the Precambrian and modified Precambrian rocks and the higher K of the rock unit referred to as quartz monzonite of San Gorgonio Mountain. The skarn of the east ridge of San Gorgonio Mountain has no noticeable expression in the radiometric data. It is concluded that the radiometric data show that radioelement distributions are within reasonable limits for the rock types involved, and there is no immediate evidence on any anomalous concentrations of radioactive elements within the Wilderness Area.

Outside of the Wilderness Area boundary, the area south of the north branch of the San Andreas fault is characterized by low values of the three radioelements, especially of eU. These data suggest a different lithology for this area compared to the remainder of the San Gorgonio survey area. As this area is fault-bounded, structural dislocation can juxtapose differing bodies of rock.

The mineralization at Alger Creek is associated with relatively higher values of eTh and K and moderate values of eU. This association is not unexpected, because the minerals known to be present comprise an assemblage that should result in anomalous values of all radioelements. If the minerals are present in sufficient quantity, it is concluded that these relatively low values are not anomalous for the study area and that the occurrence of mineralization similar to that of Alger Creek cannot be deduced from the radioelement data. Also, the radiometric data show nothing distinctive for the outcrops of Paleozoic limestone within the study area.

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INTERPRETATION OF AN AERIAL RADIOMETRIC SURVEY OF THE SAN GORGONIO WILDERNESS AREA AND VICINITY, SAN BERNARDINO COUNTY, CALIFORNIA

By
James A. Pitkin and Joseph S. Duval

1981

INTERIOR—GEOLOGICAL SURVEY, RESTON, VIRGINIA—1981

For sale by Branch of Distribution, U.S. Geological Survey, Box 25286, Federal Center, Denver, CO 80225