NATIONAL URANIUM RESOURCE EVALUATION
AERIAL RADIOMETRIC AND MAGNETIC SURVEY
NATIONAL TOPOGRAPHIC MAP

SAN ANTONIO
TEXAS

FINAL REPORT

MAY 1980

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PREPARED FOR U.S. DEPARTMENT OF ENERGY
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Grand Junction Office, Colorado

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AND BENDIX FIELD ENGINEERING CORPORATION SUBCONTRACT NO. 80-418-S

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AERIAL RADIOMETRIC AND MAGNETIC SURVEY
SAN ANTONIO NATIONAL TOPOGRAPHIC MAP
TEXAS
WEST TEXAS PROJECT

PREPARED FOR THE U.S. DEPARTMENT OF ENERGY
GRAND JUNCTION OFFICE
GRAND JUNCTION, COLORADO

UNDER BENDIX FIELD ENGINEERING SUBCONTRACT NO. 80-418-S
BY
GEODATA INTERNATIONAL, INC.
DALLAS, TEXAS

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ABSTRACT

The results of analyses of the airborne gamma radiation and total magnetic field survey flown for the region identified as the San Antonio National Topographic Map NH14-8 is presented in this report. The airborne data gathered is reduced by ground computer facilities to yield profile plots of the basic uranium, thorium and potassium equivalent gamma radiation intensities, ratios of these intensities, aircraft altitude above the earth's surface, total gamma ray and earth's magnetic field intensity, correlated as a function of geologic units. The distribution of data within each geologic unit, for all surveyed map lines and tie lines, has been calculated and is included. Two sets of profiled data for each line are included, with one set displaying the above-cited data. The second set includes only flight line magnetic field, temperature, pressure, altitude data plus magnetic field data as measured at a base station. A general description of the area, including descriptions of the various geologic units and the corresponding airborne data, is included also.

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SECTION I

INTRODUCTION

SECTION I.

INTRODUCTION

A. SURVEY AREA

Geodata International, Inc., Dallas, Texas, conducted an airborne gamma ray and total magnetic field survey for the San Antonio National Topographic Map Sheet as outlined in Figure I.1. This survey was performed from a fixed-wing aircraft, using a computer-controlled, large-volume radiation detector system to detect the gamma radiation flux emanating from the surface materials. Each map line was flown in an east-west direction with line lengths of 120.0 miles; each tie line was flown in a north-south direction with line lengths of 69.0 miles. Map lines and tie lines are located as shown in Figure II.1.

Sections I through IV of this report present information and results associated with this specific survey. Section V gives the data acquisition and the processing procedures which are generally applicable to any survey flown with the equipment described.

B. SUMMARY OF MAP LOCATION, GEOLOGY AND PHYSIOGRAPHY

The San Antonio National Topographic Map Sheet (N.T.M.S., 1954) represents a portion of southcentral Texas which is bounded by latitudes 29°00' to 30°00' north and longitudes 98°00' to 100°00' west. The map area includes all or part of the following counties: Atacosa, Bandera, Bexar, Comal, Frio, Kendall, Guadalupe, Hays, Kerr, Real, Medina, Uvalde, Wilson and Zavada.

The map sheet area is included within two distinct physiographic regions, which expose geologic units of different age and type (Figure I.2). The Edwards Plateau and the West Gulf Coastal Plain are separated by the Balcones Fault System, a zone which trends northeast-southwest across the map in the vicinity of the city of San Antonio. Cretaceous-aged, marine and transitional (predominantly chemical and bioclastic) rocks are exposed on the Edwards Plateau; Tertiary transitional and continental clastics outcrop in the Coastal Plain region of the map area.

The majority of the ^{208}Tl , ^{214}Bi and $^{214}\text{Bi}/^{208}\text{Tl}$ anomalies recorded in the San Antonio map sheet are found in the Cretaceous units and, to a lesser extent, the Tertiary units.

Figure I.1 Survey Index Map

SECTION II

FLIGHT OPERATIONS

SECTION II.

FLIGHT OPERATIONS

A. SURVEY TIME SUMMARY

The San Antonio map sheet was flown between February 22 and 26, 1980. A detailed list of dates flown and lines flown on those dates, as well as average altitude and speed for those dates, appears in Appendix I.A.

B. LINE COORDINATE LOCATION

Doppler navigation system data have been used to locate the positions of the flight lines. These lines are positioned and verified by point locations, determined by visual sighting by the navigator or photographic recovery, and corresponding record numbers displayed by the on-board computer. The data are then plotted as solid lines with ticks every ten records, circles every fifty records, and record numbers every one hundred records. Record numbers and circles also appear at the end of each line. The points used for location reference (at least every 10 miles) are marked with an "X". The flight base is then photographed with the geologic base map to produce the composite map in Figure II.1.

C. TEST LINES

When conditions allow, two five-mile test lines are flown, one at the beginning of the day and one at the end of the day, over the same base. The data are used to check the repeatability of the system's measurements, and are presented in Appendix I.B.

D. MAGNETIC DIURNAL CORRECTION - BASE STATION

A base station magnetometer is set up in the area to acquire data pertaining to the diurnal changes in the magnetic field. These data are analyzed to evaluate a diurnal correction to the magnetic data obtained by the aircraft. A list of these corrections appears in Appendix I.C.

E. ALTITUDE AND GROUND SPEED SUMMARY

The average altitude and ground speed for each line is determined. A list by date appears in Appendix I.A, and is discussed in Section II.A. A list by flight line is given in Appendix I.E.

GEODATA INTERNATIONAL, INC.
7035 JOHN W. CARPENTER FRWY DALLAS, TEXAS 75247

NATIONAL GAMMA RAY MAP SERIES

San Antonio, Texas

FLIGHT BASE

REF NTMS, NH14-B
PREPARED FOR
U.S. DEPARTMENT OF ENERGY

II-2

"x" INDICATES FILM VERIFIED POINTS

Figure II.1 NTMS Showing Flight Line Location

SECTION III

GEOLOGY OF THE SURVEYED AREA

SECTION III.

GEOLOGY OF THE SURVEYED AREA

A. LOCATION and GENERAL PHYSIOGRAPHY

of southcentral Texas. The San Antonio National Topographic Map Sheet area (N.T.M.S., 1954) is bounded by latitudes 29°00' to 30°00' north and longitudes 98°00' to 100°00' west. The map area includes all, or part of, the following counties: Atacosa, Bandera, Bexar, Comal, Frio, Kendall, Guadalupe, Hays, Kerr, Real, Medina, Uvalde, Wilson and Zavada.

The San Antonio map sheet area is included within both the Great Plains and the Coastal Plain topographic provinces (Fenneman, 1931).

In the former province, the map area is situated in the Edwards Plateau section. This section is characterized geomorphologically as a young plateau with a mature margin of moderate to strong relief. The broad interior of the Edwards Plateau is typically an extensive, grass-covered plain.

The southeastern portions of the map sheet area are included within the West Gulf Coastal Plain section of the Coastal Plain province. The region is described as a young, grading inland to a mature coastal plain.

A distinction between the two topographic regions in the map sheet area is expressed as a difference in the amount of relief. The Edwards Plateau area appears to have a much steeper slope, while the West Gulf Coastal Plain region is relatively flat. The division between the two topographic regions is the Balcones Fault Zone, which trends northeast to southwest across the map.

The rivers which drain the area include the Frio, Dry Frio, Guadalupe, Leona, Medina, Nueces and Sabinal, although the latter two are apparently intermittent. Numerous creeks run intermittently as well, and feed into the major drainage system in the map area.

B. GEOLOGY

The structural and depositional history of the San Antonio map sheet area (Figure I.2) is described by Fowler (1957), Wilson and Majewski (1960), Young (1960), Tipsword (1962), Bay (1977) and Galloway et.al. (1979), and these data are summarized as follows.

Paleozoic Era

The Paleozoic rock-record for the area has been reported predominantly from well-log information. Prior to Cambrian rock deposition, a peneplain existed over the San Antonio region. Deposition was initiated by transgression northward of a late Cambrian sea. With the exception of a post-Silurian regression, marine conditions persisted throughout most of the Paleozoic era.

A major geosyncline reportedly formed (Young, 1968) during early Pennsylvanian time, and rapidly filled with clastics from a southern source which was synchronously uplifting. Folding and faulting of the "trough" sediments followed in the Pennsylvanian period, contemporaneous with the formation of the major uplifts and basins of the foreland area of west Texas.

At the beginning of the Permian period, orogenic activity recurred along the Marathon belt, and the Val Verde geosyncline to the north deepened considerably. Subsequent to accumulation of clastic sediments into the geosyncline, a major overthrust carried pre-Permian sediments over part of the Val Verde geosyncline. The region became relatively stable at the close of the Paleozoic era.

Mesozoic Era

The oldest rock exposed in the map sheet area is the Lower Cretaceous Hensell Sand, which represents a portion of the upper Trinity Group. It is exposed in the most offset portions of the Balcones Fault system, and, in the map sheet area, it outcrops only in exposures of the Guadalupe River in the northeastern corner of the map. Interpretations for these deposits and the lower portions of the overlying Glen Rose Formation have been made (Bay, 1977) based on inferred degrees of water depth, energy and salinity. From these parameters, a depositional sequence of the following was derived: 1) marine to relatively restricted tidal-flat origin of Hensell to basal Glen Rose rocks; 2) a slightly deeper-water environment of deposition with relatively good water circulation (as evidenced by the presence of rudistid reefs, etc.) during lower Glen Rose deposition; and 3) renewed restriction of water circulation during upper Glen Rose deposition and increased salinity (marked by the *Corbula* bed which separates the two Glen Rose units).

The Lower Cretaceous rocks in the survey area are thought (Fowler, 1957) overall to represent a generally simple transgressive series deposited in a basin that was gradually subsiding in the direction of the Gulf of Mexico. In later, Early Cretaceous time, the edge of the continental shelf extended in a southwesterly direction from central McMullen County across to LaSalle County, due south of the map area. A narrow rudistid reef marked the edge of the shelf

during deposition of the Edwards Limestone and other members of the Fredricksburg Group.

Following deposition of the Upper Cretaceous Washita Group units and synchronous with late Eagle Ford Group deposition, movement along the Balcones and Luling fault systems was initiated (according to Galloway et.al., 1979, the Balcones uplift occurred during the Miocene), and produced a major unconformity and abnormal thicknesses in the Eagle Ford Shale. The unit is thickest on the down-thrown sides of the normal faults which affect it.

The Balcones Fault system is described (Fowler, 1957) as an arcuate fault belt, consisting predominantly of large, discontinuous, coastward-dipping, normal faults which trend from Williamson to Medina counties. Maximum displacement along the system is in the central portion of the belt, where individual faults may have as much as 500 feet of displacement at the surface. The western end of the belt is a complex set of numerous, small fault blocks.

The Luling Fault system trends parallel to the Balcones belt, and is delimited from the former by the landward-dip of the normal faults which comprise it.

The Cretaceous-aged igneous rocks in the map area were apparently emplaced in association with submarine volcanic activity on the ancient sea floor prior to or during Austin Group deposition. The Austin Chalk Formation has localized seams of bentonite. The upper Taylor Group and the Navarro Group followed deposition of the Austin Chalk. They consist predominantly of marine clastics, representative of prevailingly regressive conditions.

The close of the Mesozoic Era saw the formation of the Gulf Coast geosyncline from subsidence that continued throughout the Cenozoic Era. The overall regional shape of the geosyncline is thought (Hardin, 1962) to have been controlled by earlier Precambrian- and Paleozoic-aged structures. The Rio Grande Embayment was formed at this time.

Cenozoic Era

Paleocene units are absent in outcrop from the San Antonio map sheet area. The Eocene-aged Midway and Wilcox rocks were deposited in the basin. The units consist chiefly of clastics; their glauconitic (chemical deposit) fractions are suggestive of fluctuations in the supply of clastics to the basin.

According to Fowler (1957), deposition of the Wilcox presumably marked the time of maximum growth of faults and folds in the map area. Folding continued through the Eocene epoch and deposition of the Clairborne Group clastics.

As the rate of sedimentation exceeded the rate of structural downwarping of the geosyncline, the depocenters migrated. Between Eocene and Quaternary times, the geosynclinal depocenter in the northern Gulf of Mexico gradually shifted from the Rio Grande Embayment northeastward to southern Louisiana.

The Eocene units of the San Antonio map sheet appear to be dipping toward the Gulf of Mexico in a dip that is slightly greater than the slope of the land surface. This attitude exposes progressively younger beds from northwest to southeast across the map. The youngest Eocene unit surveyed is exposed only in the southeastern-most corner of the map. The unit in question, the Caddell Formation, is included in the uranium-bearing Jackson Group. Deposition of gravels and smaller clastic material has been effected by streams and flooding from the upper Tertiary or lower Quaternary periods to the present.

C. DESCRIPTION OF GEOLOGIC MAP UNITS

A brief description of the outcropping geologic units in the San Antonio map sheet area is given, based on descriptions from Trowbridge (1932), Corpus Christi Geological Society (1959), and the Geologic Map (Figure 1.2). Thicknesses of the units are indicated where known.

Cenozoic

Quaternary

Qal: Alluvium

Floodplain deposits.

Qat: Low Terrace Deposits

Mostly low terrace deposits above flood level along entrenched streams, some alluvium; gravel, sand, silt, clay, and organic material. The fluvial morphology is well-preserved with point bars, oxbows, and abandoned channel segments. Most of the rivers below the Balcones Escarpment are entrenched (rejuvenated), and do not have active floodplains; some exceptions are the Nueces River, part of the Medina River, and the San Antonio River below the mouth of the Medina.

Qf: Alluvial Fan Deposits and Colluvium

Caliche-cemented, poorly sorted, angular to rounded rock fragments of locally-derived material. Common in the western portion of the map sheet area and north of the Balcones Escarpment.

Qt: Fluvial Terrace Deposits

Gravel, sand, silt and clay. Adjacent to the Edwards Plateau, the unit is predominantly gravel, limestone and chert. Southeastward, in the vicinity of the Tertiary rocks, the unit contains increasing amounts of sand, silt and clay.

Tertiary-Quaternary

T-Qu: Uvalde Gravel

Caliche-cemented gravel with some boulders up to one foot in diameter. The unit contains well-rounded cobbles of chert, some cobbles of quartz, limestone and igneous rock. The formation occupies topographically high areas not associated with the present drainage, and it forms extensive deposits in Medina and Uvalde counties. The thickness ranges from several feet of gravel lag to ± 20 feet.

Tertiary

Eca: Caddell Formation

Siltstone, clay and sandstone. The siltstone is tuffaceous with a blocky fracture. The clay is bentonitic and locally fossiliferous. The sandstone is very fine-grained, glauconitic and light-grey to olive. The unit is generally poorly exposed, and produces a dark, reddish-brown soil. Fifty feet thick. Included in the Jackson Group.

Ey: Yegua Formation

Sandstone and clay; sandstone, mostly quartz, some chert, fine-grained, indurated to friable, calcareous, glauconitic, massive, laminated and cross-bedded. The sandstone weathers to a loose, ferruginous yellow-orange and reddish-brown soil. The clay is lignitic, sandy, bentonitic, silty, predominantly well-laminated, chocolate-brown to reddish-brown in color, and it becomes lighter in color upward. The clay produces a dark-grey soil. The unit contains some fossil wood. Approximately 1,000 feet thick.

Ecm: Cook Mountain Formation

The unit is comprised of clay and sandstone. The clay is gypsiferous, slightly silty and lignitic, with minor amounts of glauconite. Brown to brownish-grey in color, it weathers from brownish-grey to yellowish-grey. The sandstone near the top and at the base of the unit is very fine-grained, calcareous, and glauconitic. Grey to yellowish-brown in color. Marine megafossils and microfossils are abundant. Approximately 230 feet thick. This unit, along with the units Es, Eep, Ew, Eqc, Eb, Er and Ec, is included in the Clairborne Group.

Es: Sparta Sand

Quartz sand, very fine- to fine-grained, well-sorted, micaceous, some silty clay partings and interbedded siltstone. Light-grey to pale-orange to greyish-brown in color; weathers yellowish-brown to reddish-brown. Approximately 130 feet thick.

Eep: El Pico Clay

Clay, sandstone and coal. Predominantly clay, in part gypsiferous. Medium-grey to brown in color. Thin-bedded to massive. Friable to indurated. The lower 100 feet of the unit outcrops in the map sheet area. Equivalent to the units Ew and Eqc.

Ew: Weches Formation

The unit consists of greensand, sand and clay. The greensand is predominantly glauconite and, in part, marly; quartz sand is common; pale to green to yellowish-brown in color. The clay is interbedded, silty, glauconitic, dark-brown to chocolate-brown in color; it weathers to a light to dark reddish-brown color. The thickness of the formation is ± 30 feet.

Eqc: Queen City Sand

Sandstone and siltstone. The sandstone is fine- to medium-grained, well-sorted, noncalcareous, friable to indurated, commonly massive, may be finely laminated, cross-bedded, light-grey to yellow-orange. The siltstone is light-grey, friable, thin interbeds of clay, sandy, silty, light-grey to olive-green. Weathers to a mottled red and white color. The thickness of the unit ranges from 250 to 500 feet in the map sheet area.

Eb: Bigford Formation

Siltstone, sandstone and clay. The siltstone is, in part, non-calcareous, medium-grey in color, indurated, partly argillaceous, sandy, calcareous, light yellowish-grey. The clay is silty, gypsiferous, light-grey to chocolate-brown. Plant fragments are common. The unit ranges from 50 to ± 200 feet thick.

Er: Reklaw Formation

The Reklaw Formation is comprised of sandstone and clay. The sandstone constituent is fine- to medium-grained with abundant hematite, muscovite and glauconite; friable to highly indurated, thin-bedded to massive, well-developed cross-bedding, with some pelecypod casts. The clay is silty and lignitic, chocolate-brown to light-grey in color. It weathers to a moderate brown and dark, yellowish-orange color. Approximately 50 feet thick.

Ec: Carrizo Sand

Sandstone, medium- to very coarse-grained up to the size of rice, finer-grained toward the top of the unit. The Carrizo Sand is poorly sorted, friable to locally indurated, noncalcareous, thick-bedded, light-yellow to orange and brown in color. The unit weathers to a yellowish-brown, with bands of iron-oxide locally present; it is characterized by ridges that are thickly forested with oak in the eastern portion of the map sheet area. The unit thickens westward, from 140 to 200 feet.

Ei: Indio Formation

Sandstone, shale, siltstone and lignite. The sandstone is characteristically fine-grained, thin-bedded to laminar, and vari-colored in greys, yellows, greens and browns. The shale is carbonaceous, laminar, greenish-grey to medium-grey and chocolate-brown. The siltstone is thin-bedded to laminar. The unit includes some beds of lignite and many calcareous and arenaceous concretions. Approximately 440 feet thick. Equivalent to the Wilcox Group, east of the Frio River.

Ewi: Wilcox Group

Comprised predominantly of mudstone with varying amounts of sandstone and lignite. The uppermost and lowermost portions of the unit are commonly glauconitic. The mudstone is massive to thin-bedded with some silt and very fine sand laminae. The mudstone is pale-brown to yellowish-brown in the upper portion, and medium- to dark-grey, weathering yellowish-grey in the lower portion. The sandstone in the lower portion is very fine-grained, yellowish-brown to moderate brown, and in the upper portion is very fine-grained, yellowish-brown to a moderate brown in color. The lignite is found predominantly near the middle of the unit. The lower contact with the Midway Group (unit Emi) is gradational, and thus is hard to detect. Approximately 440 to 1200 feet thick.

Emi: Midway Group

This unit is comprised of clay and sand. The clay is silty and sandy, and increases in silt and sand content upward, grading to the mudstone and sand of the overlying Wilcox Group. The clay of the Midway Group is characteristically light-grey to dark-grey in color. The sand component is glauconitic to very glauconitic in the lower portion, argillaceous and poorly sorted. Phosphatic nodules and pebbles are common in the lowermost portion. The unit weathers to a yellow and yellowish-brown soil. Approximately 100 to 400 feet thick.

Mesozoic

Cretaceous

Kes: Escondido Formation

Shale, siltstone and sandstone. The shale is grey to a bluish-grey. The siltstone is brownish-yellow in color and thin-bedded. The sandstone component is fine-grained, calcareous, and, in part, asphaltic, argillaceous, grey-colored, flaggy bedded. The unit contains some pyroclastic material. Marine megafossils are common. The unit is generally poorly exposed. Thickens eastward from 200 to 500 feet thick.

Kknm: Navarro Group and Marlbrook Marl, Undivided

The upper portion of this unit consists of marl, clay, sandstone and siltstone. The marl and clay are glauconitic, and contain concretions of limonite and siderite. The sandstone is fine-grained, and, along with the yellow-brown siltstone, contains concretions of hard, bluish-grey siliceous limestone 2 to 10 feet in diameter. The sandstone beds have little lateral continuity, and become more abundant westward. This upper portion is up to 580 feet in thickness.

The lower portion consists of clay which is dominantly montmorillonitic, unctuous, and greenish-grey to brownish-grey in color. The clay weathers to a very thick, black, clayey soil. Approximate thickness of the lower portion of the unit is 400 feet. The Marlbrook Marl is thought to be equivalent to the San Miguel Member of the Taylor Group in the vicinity of the town of Del Rio. Both the Navarro Group and the Marlbrook Marl become the Escondido Formation (unit Kes) west of Bexar County.

Kac: Anacacho Limestone

This unit is composed of limestone and marl. The limestone is light-yellow to yellow-brown and light-grey in color, thick-bedded, in part cross-bedded, fossiliferous. It alternates with the marl, which is light-grey to yellow in color. The unit is, in part, sandy with some volcanic rock fragments and weathered, rusty bentonite beds. Marine megafossils are abundant. Thickness up to 500 feet, and thins to a feather-edge in western Bexar County.

Kpg: Pecan Gap Chalk

Chalk and chalky marl comprise the unit. It is light-yellow to yellowish-brown, and becomes more calcareous westward. Weathers to form moderately deep soil that is seldom exposed. *Exogyra ponderosa* is common. The unit ranges in thickness from 100 to 400 feet, and thins westward to eastern Medina County where it is overlain by the Anacacho Limestone (unit Kac); beyond this point, it is included with the Austin Chalk.

Kau: Austin Chalk

Chalk and marl. The chalk is predominantly microgranular calcite with minor foraminifera tests and *Inoceramus* prisms. It averages approximately 85% CaCO₃, and is a ledge-former. The chalk is greyish-white to white, and alternates with the marl. There are localized bentonitic seams. The marl is recessive and sparsely glauconitic, and pyrite nodules which are partly weathered to limonite are common. There are occasional beds with large-scale cross-stratification. Locally highly fossiliferous. The unit thickens westward from 350 to 850 feet.

Ki: Cretaceous Igneous Rocks

The igneous rocks in the San Antonio map sheet area are alkalic basalts and pyroclastic rock that is altered to nontronite. They are in the form of sills, laccoliths, volcanic necks, and dikes.

Kef: Eagle Ford Group

Shale, siltstone and limestone, with the upper portion consisting of limestone and shale. The limestone is flaggy, and light yellowish-brown in color. The lower portion of the unit is comprised of siltstone and very fine-grained sandstone; it is light-yellow to grey in color, laminated, flaggy with minor amounts of laminated, silty, medium-brown limestone. The entire unit is 30-75 feet thick, and is thickest in western Uvalde County.

Kbu: Buda Limestone

Fine-grained, bioclastic limestone that is commonly glauconitic, pyritiferous, hard, massive, poorly bedded to nodular, and more thinly bedded and argillaceous near the upper contact. The unit is light-grey to pale-orange in color, and weathers dark-grey to brown. Burrows are filled with a chalky marl. Abundant pelecypod fossils are present. The unit ranges from 60 to 100 feet thick, thickening westward.

Kdr: Del Rio Clay

The unit Kdr is characteristically calcareous and gypsiferous, becoming less calcareous and more gypsiferous upward. Pyrite is common. The unit is blocky, medium-grey in color, and weathers to a light- to yellowish-grey. There are some thin, lenticular beds of highly calcareous siltstone; marine megafossils include abundant *Exogyra arietina* and other pelecypods. The unit is 60-120 feet thick, thickens westward.

Kdvr: Devils River Limestone

Limestone and dolomite. The unit is hard, miliolid, pellet, rudistid with shell fragments biosparite and lime mudstone. It is

locally dolomitized, brecciated and chert-bearing. Rudistid mounds are more common in the upper portions; nodular limestone is present in the basal portions. Approximately 700 feet thick. Includes the Edwards Limestone, the McKnight Formation and the Segovia Member in the mapped area.

Ksa: Salmon Peak Limestone

The upper portion of the unit is granular, cross-bedded limestone with abundant caprinid and other shell fragments; it is 75 feet thick. The lower portion is characterized as a white, *Globigerina* mudstone with abundant, large chert masses. The total thickness of the unit is 380 feet.

Kwn: West Nueces Formation

The uppermost 80 feet of the formation is comprised of limestone, which is fine-grained, massive, miliolid and mollusc-bearing. The lower 60 feet consists of nodular limestone, oysters and other, commonly-occurring molluscs. Total thickness is approximately 140 feet.

Kft: Fort Terrett Member

Limestone and dolomite. The upper quarter consists of porcelaneous aphanitic limestone, collapse breccia, chert and recrystallized limestone. The middle portion is light- to dark-grey in color, cherty, miliolid, shell fragments, rudistid limestone and medium, brownish-grey dolomite. In the lower quarter, nodular limestone is present with thin, yellow, *Exogyra texana*-rich clay at the base. Thickens southward from 230-300 feet.

Kgru, Kgrl: Glen Rose Formation

Limestone, dolomite and marl as alternating resistant and recessive beds forming staircase topography. The limestone is aphanitic to fine-grained, hard to soft and marly, and light-grey to yellowish-grey in color. The dolomite is fine-grained, porous, and yellowish-brown in color. Marine megafossils include molluscan steinkerns, rudistids, oysters, and echinoids.

The upper portion, unit Kgru, is relatively thinner bedded, more dolomitic, and less fossiliferous than the lower portion. Approximately 400 feet thick.

The lower portion, unit Kgrl, is more massive, and contains some rudistid reefs. At the top of unit Kgrl, and separating the Glen Rose Formation into upper and lower units, is a *Corbula* bed, with abundant steinkerns of *Corbula harveyi* (Hill) in an interval up to 5 feet thick. The lower unit is approximately 500 feet thick. Total thickness of the Glen Rose Formation is 900 feet.

Kh: Hensell Sand

Limestone and sandstone comprise the unit. The upper half is a limestone, sandy, glauconitic and honeycombed-nodular. The lower half is predominantly sandstone that is fine-grained, argillaceous, calcareous, and contains white, hard, siliceous geodes up to 8 inches in diameter; yellowish-brown in color. The fossils present include the pelecypod, *Exogyra* and oysters. Thickness of the unit is approximately 45 feet.

D. RADIOACTIVE MINERAL PROSPECTS in the SURVEYED AREA

Uranium ore was located in Texas in 1954 (Southern Interstate Nuclear Board, 1969). Within two years of that date, a number of prospects were recorded along a 300-mile strip of Eocene to Pleistocene strata, extending from the central to the southernmost portion of the Coastal Plain region. The uranium ores which were first mined were shallow, unconsolidated, and well suited to be strip-mined. The later ore bodies were deeper beneath the surface, had a high lime content (Geodata International, Inc., 1979). In western Karnes County, mining and production of these deeper, unoxidized uranium deposits yielded over 10 million pounds of U_3O_8 . A total of nine companies currently operate or are developing in situ leach facilities (Galloway et.al., 1979).

Commercial and secondarily important deposits of lignite occur in the Wilcox and Jackson groups and the Yegua Formation (Kaiser, 1974). The presence of this intrinsic reductant within the rock is presumably related, along with other factors, to the occurrence of radioactive minerals in the units.

Deposits are recorded from outcrop approximately 5 miles southeast and northeast of the map area. There are, however, no known radioactive mineral prospects directly within the San Antonio map sheet area.

SECTION IV

RESULTS OF DATA ANALYSIS

SECTION IV.

RESULTS OF DATA ANALYSIS

A. DESCRIPTION OF STACKED DATA PROFILES

1. Multivariable Radiometric Stacked Data Profiles

These profiles are presented at a horizontal scale of 1:500,000. The vertical scales are:

Altitude: 100 feet/div.; aircraft altitude above the surface

TL(^{208}Tl)* 1.5 ppm/div; 7.15 c/s = 1 ppm/eTh

BI(^{214}Bi)* .5 ppm/div; 13.52 c/s = 1 ppm/eU

K (^{40}K)* .25 %/div; 98.06 c/s = 1%K

BiAir 5.0 c/s/div. .50 seconds averaged

Residual Magnetic Field 20 gammas/div. (See Sec.V.B.1)

GC (Count from 400 keV to 3.0 MeV) 400 c/s/div.

Bi/TL .09 /div.

Bi/K 1.2 /div.

TL/K 3.5 /div.

Geology Strip: An approximate six-mile width of the geology map, containing each line, is displayed above the profiles.

* 7-second average weighted 1:2:3:4:3:2:1 is used and plotted at center.

2. Residual Magnetic Field Profiles

Altitude: 100 feet/div.

Temperature: 1 $^{\circ}\text{C}$ /div.

Pressure: 3 mm of Hg/div.

Base Magnetic Field: 10 gammas/div.

Residual Magnetic Field: 10 gammas/div.

Geology Strip: An approximate six-mile width of the geology map, containing each line, is displayed above the profiles.

All profiles appear in Section IV.H.

B. SINGLE AND AVERAGE RECORD LISTINGS

Single and average record listings are provided on microfiche. Samples of each type are presented in Appendix III.

C. STATISTICAL PRESENTATION OF DATA BY GEOLOGIC TYPE

Tables IV.(1-6) contain the average value of each variable as a function of line number and geologic type. The tables are in order eTh, eU, K, eU/eTh, eU/K, eTh/K.

D. FREQUENCY DISTRIBUTION OF DATA FOR EACH GEOLOGIC TYPE

Table IV.7 contains the mean, standard deviation, and number of events for each geologic type encountered over the entire map sheet. Histograms for these data appear in Section IV.H.2.

E. DATA INTERPRETATION

1. Analysis of Geologic Histograms

The radioactivity data is shown in histogram form with parts per million or percent plotted against number of events (Appendix I). The histograms for ^{208}Tl and ^{40}K were examined for conformity to a Gaussian curve. It is generally assumed that a geologic map unit, which encompasses a fairly homogeneous lithology, would have a unimodal distribution. Where map units vary significantly from a unimodal distribution, a further subdivision into more homogeneous lithologic types may be recommended. Table IV.8 shows the map units, which vary from a unimodal model, and for which separation of two or more distributions is feasible. Only units with excess of 200 events are considered.

2. Discussion of Anomalies

Introduction

The ^{208}Tl , ^{214}Bi , and $^{214}\text{Bi}/^{208}\text{Tl}$ (ratio) data were examined for anomalous values. An anomaly is defined by a minimum of two adjacent, two-standard deviation values, or a single, three-standard deviation value. The anomalies were listed by flight line in Table IV.9; by geologic map unit in Table IV.10; Table IV.10 is statistically summarized in Table IV.11. Only positive anomalies were examined for ^{208}Tl and ^{214}Bi , but both positive and negative values were studied for the ratio anomaly.

SAN ANTONIO
TABLE: TL PPM X 10

UNIT:	QAL	QAT	QF	QT	TOU	ECA	EY	ECM	ES	EEP	EW	EOC	EH	ER	EC	EI	EWI	EMI	EES
LINE																			
ML 20:	51			55	46	60	64	73	54	48	59	53	52		53	58			
ML 40:	52			56	48		55	65	51		67	42		56	45	54			
ML 60:	49			49	38		71	67	60		91	46		49	33	51			
ML 80:	46			53	48				54		70	50		61	30		53	64	40
ML 100:	50			55	41							43		27	31		48	47	41
ML 120:	44	49		57	41							48		28	29		48	49	39
ML 140:	32	52		61	50							30		29	28		54	47	49
ML 160:	39	49	32	60	57									27			52	58	48
ML 180:	44	50		59	56									30			54	57	42
ML 200:	46	45		60	64												56	67	51
ML 220:	48	42	64	62													52	59	
ML 240:	55	54		59													53	69	
ML 260:	46	45	52	59														64	
ML 280:		34	48	57															
ML 300:		46		66															
ML 320:		33		62															
ML 340:		42		64	51														
ML 360:		36		51															
ML 380:		34		45															
ML 400:		47																	
ML 420:		38																	
ML 440:		45																	
ML 460:		38																	
ML 5020:	50	39		48		60		81	53		85	44		23	25		52	71	
TL 5040:	48			51				80	26		62	48		56	36		47	70	
TL 5060:	31	50		46								38		46	34		60	49	
TL 5080:	39	48		65	52							51		46	31		55		
TL 5100:	44	39		49	52							56		49	33		46		50
TL 5120:	49	38		59	36							43		36	50		45	55	
TL 5140:	50	30	30	53	32									46	42		52	40	36
TL 5160:	31		47	61	44								42	46					
TL 5180:	52		43	55	44								59	56					
TL 5200:	33		43	55												63			

UNIT:	KKNM	KAC	KPG	KAU	KI	KEF	KBU	KDR	KDVR	KSA	KWN	KFT	KGRU	KGPL	KH	UNK
LINE																
ML 20:																
ML 40:			42													
ML 60:			45													
ML 80:				47	53											
ML 100:			45		27	41	43	56								
ML 120:				42		35	49	59								
ML 140:					61		46	46	59							
ML 160:		40					51		63							
ML 180:	55	46		45			56	47	26	31	40					48
ML 200:	67	38	40	45		44	52		28	22	40					40
ML 220:	54		39	38			54	55	39			23				
ML 240:	61		37	41			71	58	37				26			
ML 260:	64		40	41			46	62	31				36			
ML 280:	70		52	35			57	51	32			23	31			
ML 300:	66		56				44	59	27				26	34	40	
ML 320:			54				46	55	36				21	31	43	
ML 340:		71	74	57			50	64	33				25	33	47	
ML 360:			56			45	49		33				24	33	48	
ML 380:			59	53					34				26	35	41	
ML 400:								43	38				28	27	41	39
ML 420:									37				27	28	41	39
ML 440:									46				28	35	44	36
ML 460:									39				33	34	41	
ML 5020:	70		57	34		53	45	59	57				30			
TL 5040:	57		52	48			39	70	53				35	27		
TL 5060:			33	38			37		43				40	47	34	34
TL 5080:	48		33	34			55		37				39	50		
TL 5100:			36						23			31	29	30		
TL 5120:				43				36	39			21	37	37		
TL 5140:		39		45			74		41			25	29			
TL 5160:		70		41			42		45			31	32			
TL 5180:				49	53	53		44		34		23	36			
TL 5200:				26					25	22	23	28				

Table IV.1 Geologic Unit Average Value as a Function of Map Line for eTh (PPM Times 10)

IV-3

SAN ANTONIO
TABLE: E1 PPM X 10

UNIT:	QAL	QAT	QF	QT	TOU	ECA	EY	ECM	ES	EEP	EW	EOC	EH	ER	EC	EI	EWI	EMI	EES
LINE																			
ML 20:	13			13	13	11	15	19	9	14	15	15	13		13	11			
ML 40:	14			15	14		13	18	13		15	12		15	12	16			
ML 60:	13			14	12		22	17	17		21	11		15	10	14	16		19
ML 80:	13			14	13				16		17	13		18	9		13	13	
ML 100:	13			14	12							12		7	10		14	13	12
ML 120:	13	11		14	12							14		8	10		12	13	11
ML 140:	15	14		15	13							10		8	7		14	12	12
ML 160:	12	13	13	15	14										9		14	16	12
ML 180:	15	15		14	13										7		14	15	13
ML 200:	14	12		15	14												15	16	11
ML 220:	16	12	16	14													14	14	
ML 240:	12	14		14													13	13	
ML 260:	12	14	14	15														13	
ML 280:		10	13	14															
ML 300:		16		17															
ML 320:		10		16															
ML 340:		15		16	15														
ML 360:		11		15															
ML 380:		14		15															
ML 400:		16																	
ML 420:		8																	
ML 440:		14																	
ML 460:		14																	
ML 5020:	13	15		14			18	21	16		23	14		9	8		14	18	
TL 5040:	16			17				21	9		17	14		21	14		14	16	
TL 5060:	6	15		13								10		16	13		19	15	
TL 5080:	13	15		17	14							15		13	13		16		
TL 5100:	13	14		13	17							16		16	11		16		12
TL 5120:	13	14		15	12							13		12	11		14		13
TL 5140:	16	13	14	14	11									14	13		16	13	9
TL 5160:	12		12	14	12										14				
TL 5180:	16		12	15	11								18	18	14				
TL 5200:	14		11	15												17			

UNIT:	KKNM	KAC	KPG	KAD	KI	KEF	KBU	KDR	KDVR	KSA	KWN	KFT	KGRU	KGRL	KH	UNK
LINE																
ML 20:																
ML 40:																
ML 60:		11														
ML 80:		13		14	13											
ML 100:		14		12	14	12	14									
ML 120:				12	13	10	15									
ML 140:					17	15	14	16		13						
ML 160:		11				11		20	14	10						10
ML 180:	13	14		11			15	9	13	14	12					10
ML 200:	19	13	10	10		10	12		15	13	13					20
ML 220:	14		10	9			13	13	14		16		16			13
ML 240:	13		9	12			14	14	13				12			
ML 260:	14		11	10			12	12	13				13			
ML 280:	16		12	12			14	13	12			10	11			
ML 300:	15		13				10	18	13			12	12	12		
ML 320:			14				16	15	14			11	13	14		
ML 340:	20		17	14			14	21	15			14	14	15		
ML 360:			16			20	17		14			13	14	15		
ML 380:			17	17					15			13	13	14		
ML 400:								14	14			13	12	18	24	
ML 420:									15			14	11	15	16	
ML 440:									15			14	13	17	27	
ML 460:									15			14	13	14		
ML 5020:	18		14	13		21	16	19	17			15				
ML 5040:	16		13	15			16	17	17			17		14		
ML 5060:			10	13			11		16			17		18	19	11
ML 5080:	15		9	9			16		13			15		16		
ML 5100:			11						12			13	11	14		
ML 5120:				14				14	13			10	12	10		
ML 5140:		11		11			16		15			12	12			
ML 5160:		14		10			12		17			15	11			
ML 5180:				17	15	14		16	13	13		12	12			
ML 5200:				7					14	10	15	12				

SAN ANTONIO
TABLE: K PC X 100

UNIT:	QAL	QAT	QF	QT	TQU	ECA	EY	ECM	ES	EEP	EW	EQC	ER	EC	EI	EWI	EMI	KES
LINE																		
ML 20:	86			89	58	83	84	73	66	68	79	91	72	78	109			
ML 40:	87			82	62		81	61	59		75	74		80	62	90		
ML 60:	89			82	52		84	65	63		69	93		78	48	72	89	74
ML 80:	82			88	60				52		71	81		80	39		90	86
ML 100:	84			86	63							62		39	53		99	92
ML 120:	77	86		92	58							68		31	33	108	87	61
ML 140:	38	86		93	63							27		30	31		96	85
ML 160:	60	83	32	87	54									32		107	80	69
ML 180:	61	80		77	51									40		108	92	67
ML 200:	65	56		74	41											99	81	67
ML 220:	59	64	62	68												101	75	
ML 240:	53	63		65												78	109	
ML 260:	45	54	61	66													99	
ML 280:		42	53	69														
ML 300:		60		63														
ML 320:		47		56														
ML 340:		49		52	58													
ML 360:		39		59														
ML 380:		43		51														
ML 400:		59																
ML 420:		51																
ML 440:		59																
ML 460:		50																
ML 5020:	94	55		64			85	74	59		65	60		24	19	90	91	
TL 5040:	78			77				75	55		70	83		79	57	96	102	
TL 5060:	53	77		69								87		77	40	100	87	
TL 5080:	73	75		90	61							84		67	46	105		
TL 5100:	77	61		78	58							92		82	49			69
TL 5120:	82	47		87	50							60		61	71	85		82
TL 5140:	102	41	38	76	48								47	68	58	98	71	68
TL 5160:	39		51	91	67										58			
TL 5180:	62		49	73	57								82		72			
TL 5200:	42		20	90												114		

UNIT:	KKNM	KAC	KPG	KAU	KI	KEF	KBU	KDR	KDVR	KSA	KWN	KFT	KGRU	KGRU	KH	UNK
LINE																
ML 20:																
ML 40:																
ML 60:		61														
ML 80:		74		64	73											
ML 100:		60		55	58	49	77									
ML 120:				60	40	54	71									
ML 140:					72	62	51	56		36						
ML 160:						56		85	66	26					76	
ML 180:	63	53		59				32	23	23	50				49	
ML 200:	60	42	46	46		57		70	23	17	38				39	
ML 220:	64		45	44				48	49	29				29		
ML 240:	55		42	48				49	43	28				24		
ML 260:	70		43	44				49	53	26				41		
ML 280:	61		56	46				54	40	27				37		
ML 300:	57		53					47	44	29				30		
ML 320:			54					39	45	29				24	39	
ML 340:	42		48	58				45	54	28				24	41	
ML 360:			64		57			55		24				24	39	
ML 380:			56	60						27				23	42	
ML 400:														35	46	
ML 420:								44	26					27	35	
ML 440:									27					26	39	
ML 460:									30					25	45	
ML 5020:	73		49	48	73		36	52	36					34		
TL 5040:	57		57	77			39	42	39					37	38	
TL 5060:			35	39			31		27					44	52	43
TL 5080:	77		35	45			60		32					47	53	
TL 5100:			49						22					40	41	
TL 5120:				51				20	27					30	45	
TL 5140:		55		54					29					30	37	
TL 5160:	118			34					32					29	40	
TL 5180:				66	79	62		38	26	31				21	46	
TL 5200:				41					20		17	17		26		

Table IV.3 Geologic Unit Average Value as a Function of Map Line for K (PC Times 100)

IV-5

SAN ANTONIO
TABLE: H1/TL X 100

UNIT:	QAL	QAT	QF	QT	TQU	ECA	EY	ECM	ES	EEP	EW	EQC	ER	EC	EI	EWI	EMI	KFS
LINE																		
ML 20:	26			25	29	19	23	26	18	31	26	28	26		26	19		
ML 40:	28			27	31		24	28	27		23	30		30	28	31		
ML 60:	28			30	32		31	26	30		23	25		32	32	28	30	49
ML 80:	32			28	29				30			27		30	33		26	20
ML 100:	28			26	31						25	27		25	34		30	27
ML 120:	36	24		26	30							28		29	33		27	27
ML 140:	54	27		25	26							34		29	26		26	26
ML 160:	33	28	41	26	27										37		28	29
ML 180:	37	31		26	25										25		27	27
ML 200:	34	27		26	23												27	24
ML 220:	35	32	25	24													28	24
ML 240:	23	27		26													26	18
ML 260:	28	32	29	26														
ML 280:		34	29	26													21	
ML 300:		37		27														
ML 320:		34		29														
ML 340:		40		28	31													
ML 360:		36		32														
ML 380:		43		37														
ML 400:		36																
ML 420:		22																
ML 440:		35																
ML 460:		39																
ML 5020:	27	42		32			30	26	31		28	34		40	33		29	25
TL 5040:	33			35				26	35		27	30		38	41		27	22
TL 5060:	22	31		30								28		34	39		33	33
TL 5080:	33	31		28	27							30		29	43		29	
TL 5100:	31	37		27	33							30		35	34		35	25
TL 5120:	33	41		26	35							32		41	23		33	25
TL 5140:	33	44	51	28	37									31	32		32	27
TL 5160:	41		28	25	28								43		31			
TL 5180:	31		31	31	27								31		30			
TL 5200:	54		25	28													27	

UNIT:	KKNM	KAC	KPG	KAU	KI	KEF	KBU	KDR	KDVR	KSA	KWN	KFT	KGRU	KGRU	KH	UNK
LINE																
ML 20:																
ML 40:																
ML 60:		27														
ML 80:		30		30	26											
ML 100:		33		48	36	29	26									
ML 120:				29	39	20	26									
ML 140:					28	33	32	29		32						
ML 160:		26				22		32	27	32						20
ML 180:	24	33		27			27	20	56	52	32					27
ML 200:	24	35	27	24		23	25		64	67	38					60
ML 220:	28		27	25			27	24	46		85		69			34
ML 240:	23		23	30			20	25	41				53			
ML 260:	22		30	26			28	21	49				39			
ML 280:	23		25	42			28	27	43			44	40			
ML 300:	24		25				42	31	39			47	37	35		
ML 320:			28				35	29	46			57	46	34		
ML 340:	28		24	32			24	34	51			58	46	34		
ML 360:			28			43	36		49			60	48	34		
ML 380:			30	33					49			57	43	34		
ML 400:								32	45			53	49	45	65	
ML 420:									45			56	41	39	41	
ML 440:									40			53	41	42	74	
ML 460:									42			45	40	35		
ML 5020:	26		25	41		40	40	33	33				56			
TL 5040:	29		25	33			43	24	34				53	58		
TL 5060:			33	37			31		38				45	40	56	38
TL 5080:	33		29	28			31		39				42	32		
TL 5100:			32						53			45	43	46		
TL 5120:				34				42	37			52	39	36		
TL 5140:		31		27			22		41			52	48			
TL 5160:		20		27			29		39			52	41			
TL 5180:				35	29	28		36	50	45		53	41			
TL 5200:				28					60	50	82	43				

SAN ANTONIO
TABLE: B1/K X 1000

UNIT:	QAL	QAT	QF	QT	TOU	ECA	EY	ECM	ES	EEP	EW	EQC	EB	ER	EC	EI	EWI	EMI	KES
LINE																			
ML 20:	1624			1616	2355	1389	1941	2735	1428	2223	1958	1766	2047		1955	1057			
ML 40:	1727			2067	2522		1685	3173	2421		2067	1838		2016	2108	1891			
ML 60:	1665			1934	2530		2698	2883	2793		3093	1296		2222	2535	2075	1823		2636
ML 80:	2100			1780	2423				3353		2516	1786		2428	2918		1556	1546	
ML 100:	1734			1765	2186							2131		1770	2530		1506	1456	2075
ML 120:	2445	1379		1745	2198							2135		2776	3494		1256	1687	2072
ML 140:	5130	1677		1736	2178							4144		3453	2795		1555	1587	1871
ML 160:	2734	1712	4245	1933	2804										3470		1414	2202	1792
ML 180:	3066	2197		2110	2887										2905		1395	1815	2163
ML 200:	3095	2393		2464	3941												1622	2161	1778
ML 220:	3031	2141	2674	2430													1502	1978	
ML 240:	2649	2345		2670													1845	1190	
ML 260:	2901	2830	2464	2462														1413	
ML 280:		3006	2676	2349															
ML 300:		2930		2970															
ML 320:		2530		3300															
ML 340:		3452		3771	2816														
ML 360:		3341		2785															
ML 380:		3508		3713															
ML 400:		3028																	
ML 420:		1816																	
ML 440:		2599																	
ML 460:		3104																	
ML 5020:	1453	3165		2457			2190	2962	2769		3632	2932		4088	4583		1743	1995	
TL 5040:	2057			2463				2887	1715		2461	1812		2697	2802		1395	1734	
TL 5060:	1397	2182		2192								1259		2098	4228		2013	2296	
TL 5080:	1804	2402		2043	2403							1912		2038	3409		1650		
TL 5100:	1797	2524		1810	2974							1820		2112	2479		2093		1912
TL 5120:	2153	3299		1881	2591							2382		2232	1650		1788		1688
TL 5140:	1618	3471	4083	2001	2555									2126	2544		1715	2326	1617
TL 5160:	3193		2575	1848	1998						4001				2584				
TL 5180:	2790		2817	2649	2177						2271				2426				
TL 5200:	5083		5680	1835												1506			
UNIT:	KKNM	KAC	KPG	KAU	KI	KEF	KBU	KDR	KDVR	KSA	KWN	KFT	KGRU	KGRU	KH	UNK			
LINE																			
ML 20:																			
ML 40:																			
ML 60:		1969																	
ML 80:		1835		2264	1961														
ML 100:		2528		2282	2664	2595	1888												
ML 120:				2127	3385	1866	2235												
ML 140:					2446	2588	2869												
ML 160:		3211			2167														
ML 180:	2115	3085		2117				3470	3044	6629	7450	2719				1317			
ML 200:	3420	3625	2407	2494		1851		1851		8441	8274	4470				2533			
ML 220:	2433		3097	2271		3046	3051	6595				10327		6054		3985			
ML 240:	2069		2580	2880		2959	3507	5598						6223					
ML 260:	1988		2816	2603		2687	2462	5902						3510					
ML 280:	2815		2357	3123		2730	3623	5174						3777					
ML 300:	2897		2629			3981	4130	5034						4727	3273	2544			
ML 320:			2813			4319	3557	5522						5823	3879	3443			
ML 340:	4838		3940	3302		3262	4142	6230						6523	3832	3115			
ML 360:			2634			3497	3305	6575						6318	4284	3214			
ML 380:			3054	2935				6232						6618	3669	2841			
ML 400:						3238		6180						5669	3924	4039	6006		
ML 420:								5972						6024	3234	3460	3575		
ML 440:								5507						6182	3327	3753	9877		
ML 460:								5107						4671	3045	2590			
ML 5020:	2734		2954	2805		2966	4913	3787	5243					4767					
TL 5040:	3163		2440	2128			4270	4092	4819					5010	4155				
TL 5060:			3395	4090			3784		6216					4291	3875	4698	3977		
TL 5080:	2117		2714	2287			2900		4688					3579	3131				
TL 5100:			2302						6204					4620	3271	3417			
TL 5120:				3031				8003	5369					3737	3143	2156			
TL 5140:		2255		2534			2545		5833					4818	3829				
TL 5160:		1232		3353			4052		5485					5924	3387				
TL 5180:				2582	1981	2623		4328	6400	5061				6226	3256				
TL 5200:				1829					7667	6578	10795	4897							

Table IV.5 Geologic Unit Average Value as a Function of Map Line for eU/K (Times 1000)

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SAN ANTONIO
TABLE: TL/K X 1000

UNIT:	QAL	QAT	QF	QT	TQU	KCA	EY	ECM	ES	EEP	EW	EQC	EB	ER	EC	EI	EWI	EMI	KES
LINE																			
ML 20:	6143			6355	8157	7273	7847	10197	7938	7171	7519	6136	7668		7144	5423			
ML 40:	6223			7452	7960		7023	11330	8868		8966	6001		6586	7458	6169			
ML 60:	5910			6312	7644		8520	10855	9325		13221	5050		6969	7828	7349	6019		5490
ML 80:	6063			6153	8179				11259		10006	6520		7921	8898		5898	7477	
ML 100:	6099			6740	6869							7274		6995	7087		5023	5217	6660
ML 120:	6179	5761		6575	7322							7430		9423	10677		4732	5946	7188
ML 140:	9214	6122		6878	8325												5897	6028	7008
ML 160:	7674	6026	10284	7227	10843							11672		11595	10428		5024	7535	7231
ML 180:	7917	6854		8015	11952										9696		5107	6467	6705
ML 200:	8073	8930		8836	17972										11894		6005	8891	7709
ML 220:	8616	6681	10435	9930													5452	8120	
ML 240:	11300	9022		10295													7064	6376	
ML 260:	10323	8691	8409	9359														6569	
ML 280:		8871	9324	8978															
ML 300:		7808		11025															
ML 320:		7298		12302															
ML 340:		8680		14457	8852														
ML 360:		9509		8737															
ML 380:		8200		9729															
ML 400:		8219																	
ML 420:		7961																	
ML 440:		7831																	
ML 460:		8118																	
ML 5020:	5400	7528		7645			7258	11099	9038		13172	8335		10189	13935		6065	7802	
TL 5040:	6114			6795							8943	6048			7153	6693		5232	7679
TL 5060:	5937	6962		7325								4540			6009	10724		6168	6269
TL 5080:	5600	7357		7375	8914							6328			7036	8135		5566	
TL 5100:	5742	6706		6691	9009							6012			6099	7246		6064	7651
TL 5120:	6171	8146		7113	7390							7365			5667	7098		5354	6822
TL 5140:	4956	7820	7966	7095	6902										6746	7715		5374	6354
TL 5160:	7925		9104	7225	6914									9094		8271			5850
TL 5180:	8855		9053	8096	8172											8093			
TL 5200:	8781		22333	6601										7455					
																	5587		
UNIT:	KKNW	KAC	KPG	KAU	KI	KFF	KBU	KDR	KDVR	KSA	KWN	KFT	KGRU	KGRL	KH	UNK			
LINE																			
ML 20:																			
ML 40:																			
ML 60:		7221																	
ML 80:		6248		7376	7397														
ML 100:		7610		4873	7434	8921	7297												
ML 120:				7355	8925	9205	8547												
ML 140:					8637	7689	9217	10673			13650								
ML 160:		11094				9550		7510	8022	16257							6389		
ML 180:	8962	9037		7789			12768	14797	11865	14207	8231						9010		
ML 200:	11405	10573	8806	10316		7712	7437		13674	13066	11053						11598		
ML 220:	8936		10671	9064			11444	12310	14107		12696			8350			11872		
ML 240:	12278		10321	9644			14539	13702	13845					11420					
ML 260:	8996		9468	9700			9705	11921	12426					9079					
ML 280:	12172		9593	7429			10371	13330	12322				8799	8961					
ML 300:	11937		10625				9467	13049	13188				9613	8630	7393				
ML 320:			10137				12042	12097	12375				9658	8374	9739				
ML 340:	17353		18014	10408			11228	12073	12450				11312	8382	9370				
ML 360:			9190			7988	9239		14206				10736	8913	9440				
ML 380:			10459	8983					12970				11676	8752	8187				
ML 400:							10055	14763					10827	8226	8940	9618			
ML 420:								13839					10904	7696	9032	8366			
ML 440:								13701					11644	8047	9073	13417			
ML 460:								12148					10328	7592	7506				
ML 5020:	10497		11754	7091		7324	12527	11377	16323					8817					
TL 5040:	10732		9378	6377			10724	16391	14177					9929	7280				
TL 5060:			10365	10909			11714		16067					9455	9372	8300	10990		
TL 5080:	6519		9528	8021			9370		11820					8520	9679				
TL 5100:			7277						11633				10677	7487	7241				
TL 5120:				8796				18480	15070					7280	8442	6634			
TL 5140:				8966			11260		14728					9052	8132				
TL 5160:		7238		12456			13847		14228					11212	8243				
TL 5180:		5990		7444	6975	9094		11870	12929	10979				12153	8007				
TL 5200:				6298					13126	13520	13676	11393							

eTh		eU		K		eU/eTh		eU/K		eTh/K		MAX. NO. EVENTS	GEOL. UNIT
σ	$\bar{x}$	σ	$\bar{x}$	σ	$\bar{x}$	σ	$\bar{x}$	σ	$\bar{x}$	σ	$\bar{x}$		
1.3046	4.7	0.3834	1.4	0.2705	0.8	0.1661	0.3274	1.9935	2.3662	2.3984	6.9063	2395.0	QAL
1.2883	4.5	0.4044	1.4	0.2318	0.6	0.1204	0.3356	1.1459	2.5338	2.0995	7.5737	2668.0	QAT
1.6594	4.7	0.3865	1.3	0.1991	0.5	0.1076	0.3104	1.1392	2.9068	2.9194	9.5124	256.0	QF
1.4826	5.8	0.3915	1.5	0.2747	0.8	0.0902	0.2714	1.0931	2.0717	2.9298	7.6706	13840.0	QT
1.3896	4.8	0.3553	1.3	0.1680	0.6	0.0892	0.2953	0.9401	2.4678	3.4783	8.6589	2886.0	TQU
0.3063	6.0	0.2422	1.2	0.1097	0.8	0.0438	0.1425	0.2845	1.3494	0.9907	7.2738	16.0	ECa
0.9392	6.0	0.4775	1.5	0.1253	0.8	0.0670	0.2579	0.7062	1.9180	1.5467	7.3528	320.0	EY
0.9533	7.3	0.3909	1.9	0.1291	0.7	0.0440	0.2673	0.7766	2.8497	2.2060	10.6325	439.0	ECM
1.4926	5.1	0.4612	1.4	0.1128	0.6	0.0833	0.2870	0.9459	2.5157	2.8796	8.9347	277.0	ES
0.4956	4.8	0.2071	1.5	0.1151	0.7	0.0353	0.3108	0.3725	2.2233	1.1135	7.1717	24.0	KEP
1.7995	7.1	0.5097	1.8	0.1039	0.7	0.0557	0.2522	0.8123	2.4938	2.7611	9.9343	321.0	EW
1.3140	4.8	0.4765	1.4	0.2284	0.8	0.0810	0.2936	0.9473	1.8749	2.3332	6.3463	3141.0	EOC
0.8261	5.2	0.4290	1.5	0.2337	0.7	0.0940	0.2881	0.9584	2.2663	1.7536	7.7769	311.0	EH
1.3993	4.7	0.5149	1.5	0.2666	0.7	0.0841	0.3180	1.0156	2.3146	2.5030	7.3175	1441.0	ER
1.1075	3.4	0.4030	1.1	0.2297	0.5	0.1226	0.3301	1.6839	2.7931	3.8435	8.5453	4394.0	EC
1.0117	5.4	0.4070	1.5	0.2347	0.9	0.0892	0.2818	0.6082	1.8328	1.3032	6.5564	472.0	EI
1.0083	5.2	0.3895	1.5	0.2200	1.0	0.0819	0.2856	0.5312	1.5406	1.5061	5.4944	5033.0	EWI
1.2446	5.5	0.3814	1.4	0.2327	0.9	0.0868	0.2708	0.7867	1.8030	1.9732	6.7242	951.0	EMI
0.9073	4.7	0.3130	1.2	0.1769	0.7	0.0784	0.2743	0.6208	1.9015	1.7367	7.0488	1170.0	KES
1.1429	6.2	0.3800	1.6	0.1964	0.6	0.0769	0.2589	1.0928	2.6839	3.6509	10.5844	1485.0	KKNM
1.2164	4.5	0.3825	1.3	0.2431	0.6	0.1011	0.3078	1.2375	2.5049	2.6627	8.0512	447.0	KAC
1.4652	4.8	0.3911	1.3	0.1539	0.5	0.0869	0.2720	1.0540	2.6845	3.6448	10.0709	1553.0	KPG
1.2575	4.2	0.3861	1.2	0.1656	0.5	0.1011	0.2832	1.1420	2.5445	2.9608	9.1853	1932.0	KAU
1.1080	4.6	0.3580	1.5	0.1783	0.6	0.1033	0.3276	0.8968	2.4867	1.7978	7.6566	229.0	KJ
1.0003	4.9	0.4243	1.5	0.1658	0.6	0.0909	0.3072	0.7146	2.5721	1.6874	8.5289	193.0	KEF
1.2729	5.0	0.3547	1.5	0.1473	0.5	0.0960	0.3100	1.0281	3.1520	2.8870	10.4688	761.0	KHI
1.3260	5.6	0.4470	1.5	0.1760	0.5	0.0793	0.2761	1.3674	3.4058	2.8139	12.2956	366.0	KDR
1.4774	3.6	0.3959	1.5	0.1081	0.3	0.2129	0.4603	2.9905	5.9561	4.2384	13.4021	15180.0	KDVR
1.2970	3.1	0.4011	1.2	0.1386	0.2	0.2470	0.4666	3.3809	6.4458	5.4289	14.3617	731.0	KSA
1.1515	2.7	0.4162	1.5	0.1632	0.3	0.3996	0.7011	5.6772	8.2945	4.7613	11.7517	129.0	KWN
0.9434	2.8	0.3764	1.4	0.0847	0.3	0.1929	0.5400	2.8196	5.7855	3.8000	10.8709	4371.0	KFT
1.3091	3.3	0.4071	1.3	0.1543	0.4	0.1807	0.4365	1.9260	3.6561	2.6089	8.4479	15980.0	KGRU
1.2682	4.4	0.4943	1.6	0.1327	0.5	0.1524	0.3951	1.4600	3.4639	2.4022	8.9254	4224.0	KGRU
0.8638	3.9	0.6919	1.8	0.0839	0.5	0.1664	0.4835	2.1341	4.3194	2.4995	8.6914	108.0	KH
1.0404	3.9	0.4374	1.3	0.1739	0.4	0.1915	0.3612	2.3625	3.7011	4.4371	10.5066	446.0	UNK

Table IV.7 Mean ($\bar{x}$) and Standard Deviation (σ) for Each Geologic

TABLE IV.8 Geologic Units with Apparent Significant Variations from Unimodal Distributions, Based on the Analysis of the eTh Histograms*

Geologic Unit	No. Events	²⁰⁰ Tl Recommended Split (equivalent ppm)
Qal	2395	none
Qf	256	none
Qt	13840	none
T-Qu	2886	none
Ey	320	none
Ecm	439	none
Es	277	none
Ew	321	none
Egc	3140	none
Eb	311	none
Er	1441	37
Fc	4394	none
Ei	472	none
Ewi	5033	none
Emi	951	none
Kes	1170	none
Kknm	1485	none
Kac	447	none
Kpg	1553	47
Kau	1932	none
Ki	229	none
Kbu	761	none
Kdr	366	none
Kdvr	15180	none
Ksa	731	none
Kft	4371	45,55
Kgru	15979	none

*Recommended Splits on the Histograms are Given Only Where Such Splits Appear to be Obvious.

TABLE IV.9 Summary of Anomalies

	²⁰⁸ Tl	²¹⁴ Bi	²¹⁴ Bi/ ²⁰⁸ Tl
ML20	Ec,1463-1468;Eqc,3523-3528;Ey,4088-4093	Eqc,2833-2838,3518-3523 Qt,4048-4053	T-Qu,1728-1733;Qt,2183-2193
ML40	Qa1,4610-4615;Er,5810-5820;Ec,6845-6855,6865-6900,6920-6925	Qa1,4610-4615;Qt,4690-4695;Er,5485-5490;T-Qu,5840,5850;Ec,7230-7235	Es,4835-4840;Ei,7355-7360
ML60	Ec,1620-1625,1925-1930 Eqc,3915-3925;Ew,3930-3940	Kes,1236;Ew,3930	Qt,1216,1226;Kes,1236; Ei,1271,1306;Qt,1746,1776-1781;Ec,2606-2611,2671-2676;Eqc,(3496-3501)
ML80	Eqc,1369-1374;Er,1774; Ewi,2969-2974	Er,1774;Ec,2304-2309	T-Qu,3479;Qa1,4119-4189
ML100	Eqc,7445-7460	Ewi,6480-6485,6495-6500 Eqc,7450-7455	Kau,4525,4535;Qt,4545-4550;Q-Qu,4860-4865;Ewi,6475-6485,6510-6515
ML120	Eqc,1178-1188;Ewi,1665-1670	Eqc,1178-1188;Ewi,1665	Ewi,2218,2228-2233;T-Qu,3163-3168,3183;Ki,3653;Qa1,3998-4003
ML140	Ksa,4590;T-Qu,5740-5750; Kes,5970-5980;Ewi,6275-6280	Kbu,4210-4215;Qt,4665-4670;Kes,5990-6000	Qa1,4180,4245-4255;Er,7195,(7270)
ML160	Qat,2080-2095;T-Qu,3075-3080,3090-3110,3120-3130 Kbu,3745-3750	Ewi,1315-1320;Qt,3710-3715	Ec,1033-1043,1053-1058 Ewi,(1268-1273),1288-1293,1313-1318;T-Qu,3053-3058;Qt,3538,4008-4013
ML180	Ksa,4527-4537;Qt,4737-4752;T-Qu,5757-5762	Qa1,4327;Ksa,439/-4402	Qt,5557-5562,5852;Kac,5927; Qt,6367-6372;Ewi,6927
ML200	Ewi,1624-1629;T-Qu,2709-2724;Kau,3154-3169,3184-3189	Ewi,1629-1634,1739-1744;Kac,2584;Kdvr,4010	Kac,2584;Qt,3834-3844,3959-3964;Kdvr,4009-4019,4029-4034,4054,4064;Ksa,4129-4134;Kdvr,4144-4159;Ksa,4189-4194;Kdvr,4364-4369;Qa1,4394-4399

(...) Denotes negative anomaly

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(TABLE IV.9 Cont'd.)

	²⁰⁸ Tl	²¹⁴ Bi	²¹⁴ Bi/ ²⁰⁸ Tl
ML220	Kdvr,5252-5262;Kbu,5377-5382;Kdvr,5632-5642,5972,5992-5997;Kdr,5695-5700	Kgru,4492-4497;Kdvr,5930-5940;Ewi,7410-7420	Kgru,4492-4497;Kdvr,4512,4587,4647-4652,4667-4672,4692-4697,4772,4847;Kau,(6502-6507);Qt,6607;Kknm,6847-6857
ML240	Ewi,1156-1161;Qt,2265-2275;Kdvr,3190-3200,3270-3280	Kdvr,3190-3200	Kau,1781;Kpg,(1916-1921);Kgru,3381;Qt,3896;Kdvr,4041-4046,4166-4176;Kgru,4226-4231
ML260	Kgru,5230;Kdvr,5290-5295;Kau,6155-6165;Kdvr,6280	Kgru,4360-4365;Qt,4975-4980;Kdvr,5290-5295	Kdvr,4405-4415,4560-4565,5980-5985;Kpg,6645
ML280	Kknm,1203-1208;Kdvr,1958-1963;Kgru,3048-3053,3483-3498		Kpg,1478;Kau,1688;Kdvr,3623-3633,3873-3883,4058;Kgru,4108-4113
ML300	Kgru,4972-4977,5032-5047,5057-5062,5647-5652,6362-6367,6447-6452;Kdvr,6697-6702,6817-6822;Qt,7297-7312	Kgru,5032-5042,5312-5317;Kdvr,6657-6662,6850;Qat,7275;Qt,7285-7295	Qt,4642-4647;Kgru,5442-5447;Qt,5547
ML320	Qt,1268-1278;Kdvr,1583-1588,1673-1678;Kgru,2208-2213,3253-3263	Kdvr,1568,1648-1658;Kgru,2193-2208	Kdvr,1543-1553;Kgru,2128-2133,2488;Qt,3298;Kgru,3583-3588,3873;Qt,3958;Kgru,4053-4058,4258-4263
ML340	Kgru,5170,6100-6105,6505-6510;Kgr1,6525-6530;Kgru,6780-6790;Kgr1,6795;Kgru,6800-6815;Qat,6910-6920;Kdvr,7350-7365;Qt,7460-7470,7480-7485;Kpg,7525-7540	Kgru,6775-6790,6800,6810-6815,6840-6850;Kdvr,7195-7200;Kau,7245-7250;Kdr,7285-7290;Kdvr,7315-7355	Kdvr,4450;Kgru,4475-4480,4550;Kdvr,4885;Kgru,5650;Qat,5935-5940;Kgru,6645
ML360	Kgru,1473-1478;Kgr1,1898-1903,1913-1928,2133;Kgru,2158-2163,2678-2688,2728-2738,2768-2778,2843	Kbu,1203-1208;Kgru,2198-2203	Kgru,2283-2288,3243;Kft,3433-3438;Kgru,3473-3478,3498-3508;Qt,3773-3778;Kgru,3793;Kdvr,4013-4018,4038-4048

(...) Denotes negative anomaly

IV-11b

(TABLE IV.9 Cont'd.)

	²⁰⁸ Tl	²¹⁴ Bi	²¹⁴ Bi/ ²⁰⁸ Tl
ML380	Kgru,4503-4508,5370-5395,5405-5415,5500-5510,5670,6120-6130,6200-6230,6805-6810;Kft,5995-6015	Kdvr,4953-4958,6868-6873;Kau,7298-7303	Kdvr,4223;Kft,4273,4433-4438,5113;Kgru,6103-6108,7053-7058
ML400	Kdvr,1206-1221;Kft,2386-2391,2406-2426,2491-2496,2851-2856,2871-2876;Kgru,3046-3056;Qat,3176-3181;Kgru,3186;Kdvr,3521-3531	Kgru,1511-1516;Kgr1,1701-1721,1761-1766,1806-1811;Kgru,3186	Kgru,1416;Kgr1,1501,1711-1716;Kgru,2141;Kft,2901,3196;Kdvr,3486-3491;Kft,3631;Kdvr,4036;Kft,4066;Kdvr,4121
ML420	Kft,5382-5432;Kdvr,7162-7192,7217-7222,7232-7242	Kft,5377-5407	Kdvr,5067;Kft,5152;Kgr1,6722;Kgru,7027-7032
ML440	Kgru,4254-4259,5594-5599,5694-5699	Kdvr,4114-4119;Kgru,4249-4254,4404-4429;Kgr1,4574-4579	Kgru,4414-4419,4459;Kgr1,4564,4574-4589,4614-4624
ML460	Kdvr,1761-1766;Kft,2016-2031,2131-2141;Kgru,2666-2671,3131-3136	Kdvr,1786-1791;Kgru,3811-3816	Qat,2376-2381;Kgru,3826-3831;Qat,3986
TL5020	Kknm,2184-2189;Kdvr,2774-2784,2794-2844,2854-2859,2894-2899	Eqc,1499-1504;Kef,2619;Kdvr,2664-2669,2809-2814	Eqc,(1539-1544),1669,1689;Er,1724-1734;Ec,1824;Qt,1844,1864;Kdvr,2954-2959;Kgru,2979
TL5040	Kdvr,3470-3475,3690-3695	Kgru,3313-3328;Kdvr,3465-3475,3683-3688;Emi,4128-4133;Ewi,4440,4445-4455	Kgr1,3213,3223-3233,3283-3298;Kgru,3313-3328;Kbu,3718;Qt,3798-3818;Kknm,3988;Ewi,(4383),4438-4443;Ec,4448-4458
TL5060	Kgru,6250-6255,6265-6270;Kgr1,6275-6290	Ewi,5320-5340;Kgru,6255-6265,6370-6380;Kgr1,6630-6640	Qt,4940;Emi,5490;Kgp,5880-5890;Kau,5915;Kgru,6365-6370
TL5080	Kgru,1376,1451-1456,1466-1476	Kgru,1466-1476;Ec,2481,2656	Ec,2551,2656
TL5100	Kft,4360-4375	T-Qu,2972-2982;Ewi,3252-3257	Ewi,3232-3237,3252-3262;Kgru,4502

(...) Denotes negative anomaly

IV-11c

(TABLE IV.9 Cont'd.)

	²⁰⁸ Tl	²¹⁴ Bi	²¹⁴ Bi/ ²⁰⁸ Tl
TL5120	Kgru,5100-5110,5140-5180; Kes,5945-5955;Ec,6325- 6330		Kgru,4910;Qat,4925-4930; Kdr,5674;Ewi,6200;T-Qu, 6475-6480
TL5140	Kgru,2130-2140,2190-2200		Emi,1408-1413;T-Qu,1453- 1458;Kes,1524;Qf,2238; Kgru,2463-2468
TL5160	Kdvr,3072-3082;Kft,3157- 3167,3282-3287;Kgru,3567- 3582,3597-3602;Qt,4062- 4067;Kac,4077-4087	Kft,3282-3292	Kgru,3437-3442;Eb,4727
TL5180	Ec,4880-4900	Qt,4750-4760,5425	Qt,4766-4760;Kdvr,5500- 5505;Qt,5585-5605,5640- 5650;Kdvr,6050
TL5200		Kdvr,1866-1871;Qa1, 2276-2281	Kdvr,1646-1651,1736,1756, 1776-1781,1851-1856,1986- 1996,2006-2011,2026-2036, 2066;Qa1,2491-2506,2561; Qt,2591-2596

(...) Denotes negative anomaly

TABLE IV.10 Radioactivity Anomalies per Geologic Map Unit

Geologic Unit	²⁰⁸ Tl	²¹⁴ Bi	²¹⁴ Bi/ ²⁰⁸ Tl
<u>Quaternary</u>			
Qa1	1	3	7
Qat	3	1	4
Qf	0	0	1
Qt	7	8	28
<u>Tertiary-Quaternary</u>			
T-Qu	6	3	8
<u>Tertiary</u>			
Ey	1	0	0
Es	0	0	1
Ew	1	1	0
Eqc	5	5	2 (2)
Eb	0	0	1
Er	2	2	2 (1)
Ec	8	5	8
Ei	0	0	3
Ewi	5	10	11 (2)
Emi	0	0	2
<u>Cretaceous</u>			
Kes	2	2	2
Kknm	2	0	2
Kac	1	1	2
Kpg	1	0	3 (1)
Kau	3	2	5 (1)
Ki	0	0	1
Keef	0	1	0
Kbu	2	2	1
Kdr	1	1	1
Kdvr	27	19	43
Ksa	2	1	2
Kft	12	2	9
Kgru	48	19	34
Kgrl	5	5	9

(...) denotes negative anomaly

TABLE IV.11 Statistical Summary of Radioactivity Anomalies per Geologic Period(s)

Geologic Unit	²⁰⁸ Tl	²¹⁴ Bi	²¹⁴ Bi/ ²⁰⁸ Tl
<u>Quaternary</u>			
No. of units w/anomalies	3	3	4
No. of anomalies	11	12	40
<u>Tertiary-Quaternary</u>			
No. of units w/anomalies	1	1	1
No. of anomalies	6	3	8
<u>Tertiary</u>			
No. of units w/anomalies	6	5	8
No. of anomalies	22	23	30 (5)
<u>Cretaceous</u>			
No. of units w/anomalies	12	11	13
No. of anomalies	106	55	114 (2)
<u>Total Sample</u>			
No. of units w/anomalies	22	20	26
No. of anomalies	145	93	192 (7)

(...) denotes negative anomaly

Quaternary Geologic Units: Qal, Qat, Qf, Qt

²⁰⁸Tl Anomalies

Seven and one-half percent of all the ²⁰⁸Tl anomalies reported from the San Antonio map sheet area are recorded over the Quaternary units, with the exception of the unit Qf. The majority of these anomalies are from the unit Qt. Given that the uranium ion is relatively insoluble in most surface waters, and is rarely concentrated through chemical precipitation, these anomalies are probably not economically significant.

²¹⁴Bi and ²¹⁴Bi/²⁰⁸Tl Anomalies

Thirteen percent of the ²¹⁴Bi anomalies and approximately twenty-one percent of the positive ratio anomalies are reported from the Quaternary units. There is one point of coincidence between the Quaternary ²¹⁴Bi anomalies and positive ratio anomalies: TL5180, stations 4755-4760 (Qt).

The two anomalous types recorded in the Quaternary units may be representative of minor intraunit changes in lithology, especially in view of the fact that each unit varies from a unimodal geochemical distribution (Table IV.8). Units Qal, Qat and Qt may contain concentrations of uranium ions as precipitates or adsorbed to humates and clays.

Tertiary-Quaternary Geologic Unit: T-Qu

²⁰⁸Tl Anomalies

Four percent of the ²⁰⁸Tl anomalies are found in the unit T-Qu. These are not considered to be economically significant.

²¹⁴Bi and ²¹⁴Bi/²⁰⁸Tl Anomalies

Three percent of the ²¹⁴Bi anomalies and four percent of the positive ratio anomalies are recorded over the unit T-Qu. There are no loci of coincidence between the two anomalous types in the unit. The anomalies are considered to represent lithological changes within the unit, presumably due to the varied constituents that comprise the gravel.

Tertiary Geologic Units: Ey, Es, Ew, Eqc, Eb, Er, Ec, Ei, Ewi, Emi

²⁰⁸Tl Anomalies

Fifteen percent of the ²⁰⁸Tl anomalies are reported from Tertiary units, in particular the units Eqc, Ec and Ewi.

²¹⁴Bi and ²¹⁴Bi/²⁰⁸Tl Anomalies

Twenty-five percent of the ²¹⁴Bi anomalies and approximately sixteen percent of the positive ratio anomalies are recorded from the Tertiary units. There are six points of coincidence between the Tertiary ²¹⁴Bi and positive ratio anomalies: ML100, stations 6480-6485 (Ewi); ML160, stations 1315-1318 (Ewi); TL5040, station 4440 (Ewi and stations 4448-4455 (Ec); TL5080, station 2656 (Ec); and TL5100, stations 3252-3257 (Ewi).

The uranium-bearing characteristics of Tertiary units of the Texas Gulf Coastal Plain have been reported from several sources (Southern Interstate Nuclear Board, 1969; Gableman, 1977; Galloway et.al., 1979; and others). It is generally believed that volcanic ash served as source rock for the uranium. Glauconitic sandstone members of the Clairborne Group (units Ey and Ew) are reported to have anomalous radioactivity due in part to metamict zircon in the units (Southern Interstate Nuclear Board, 1969). The Wilcox Group units are anomalous where they contain localized lenses of ferruginous sandstone, and this characteristic may explain the anomalous occurrences in the unit Ewi.

Throughout most of the Tertiary units, organic material is deposited which can act as an intrinsic reductant for concentration of uranium ions.

Cretaceous Geologic Units: Kes, Kknm, Kac, Kpg, Kau, Ki, Kef, Kbu, Kdr, Kdvr, Ksa, Kft, Kgrou, Kgrl

²⁰⁸Tl Anomalies

Seventy-three percent of the ²⁰⁸Tl anomalies are recorded over the Cretaceous units, which outcrop over greater than one-half of the map area.

²¹⁴Bi and ²¹⁴Bi/²⁰⁸Tl Anomalies

Fifty-nine percent of both the ²¹⁴Bi anomalies and positive ratio anomalies are recorded from the Cretaceous units. There are eight points of coincidence of ²¹⁴Bi and positive ratio anomalies: ML60, station 1236 (Kes); ML200, station 2584 (Kac) and station 4010 (Kdvr); ML220, stations 4492-4497 (Kgrou); ML440, stations 4414-4419 (Kgrou) and stations 4571-4579 (Kgrl); TL5040, stations 3313-3328 (Kgrou); and TL5060, station 6370 (Kgrou).

Non-coincidental anomalies may be a function of intraunit changes in lithology (Table IV.8). The units Ki, Kes and Kac

are reported (Section III-C) to contain pyroclastics, which may be responsible for the anomalies within the units.

Relationship between Radioactivity Anomalies and Known Radioactive Mineral Deposits

There are no reported radioactive mineral deposits in the San Antonio map sheet area (Section III-D).

Relationship between Radioactivity Anomalies and Cultural Features in the Surveyed Area

Cultural features which may affect the radioactivity data recorded in the San Antonio map sheet area include the city of San Antonio, the towns of Floresville, New Braunfels, Poteet, Devine, Boerne, Ingenhuett, Hondo, Sabinall and Uvalde, and the Lackland and Randolph Air Force bases. Major bodies of water include Mitchell and Medina lakes and the Canyon Reservoir. The Guadalupe, Frio, Dry Frio, Medina and Nueces rivers may also affect the recorded data.

There are two positive ratio "anomalies" recorded over the canyon reservoir: TL5040, station 3270 and stations 3280-3290. These "anomalies" are presumably caused, in part, by a variance in water level in the reservoir.

There are several ratio anomalies distributed around, and possibly associated with, the city of San Antonio: ML180, stations 6367-6372 (Qt); ML220, station 6607 (Qt) and stations 6847-6857 (Kknm); ML240, station 1781 (Kau) and stations 1916-1921 (Kpg); and TL5060, station 5490 (Emi) and stations 5880-5890 (Kpg).

One ²¹⁴Bi anomaly, ML120, station 1665 (Ewi) appears to be associated with Lake Braunig.

²⁰⁸Tl Anomalies

The ²⁰⁸Tl anomalies in the San Antonio map sheet area are not distributed in specific patterns across the map. They are, however, absent from the extreme western portion of the map area. There appear to be more ²⁰⁸Tl anomalies on the Edwards Plateau region of the map.

²¹⁴Bi Anomalies

The ²¹⁴Bi anomalies are clustered into four loose aggregates in the map area. The first cluster lies in the southwestern quarter of the map, in the approximate vicinity of the town of Uvalde. The second grouping is located approximately between longitudes 99°15' and 99°30' and north of latitude 29°30'.

The third and fourth clusters lie in the northeastern and southeastern corners of the map area, respectively.

$^{214}\text{Bi}/^{208}\text{Tl}$ Anomalies

There are four very generalized patterns of distribution of the San Antonio map ratio anomalies. The first trend is a general paucity of anomalous values in the central portion of the map. The second is a concentration of anomalies around the extreme western portion of the map. The third pattern is a tendency for the anomalies to cluster around the city of San Antonio. The fourth clustering is located in the northeastern corner of the map area.

3. Summary and Recommendations

The majority of the ^{208}Tl , ^{214}Bi and $^{214}\text{Bi}/^{208}\text{Tl}$ anomalies in the San Antonio map sheet area are recorded over the Cretaceous-aged units of the Edwards Plateau region and lower Tertiary units of the West Gulf Coastal Plain region. According to Galloway, et.al. (1979), since tuff occurs in rocks of Jackson Group age, potential sources of uranium are contained within all mineralized host aquifer systems of Tertiary age younger than Jackson. Cretaceous deposits with localized concentrations of carbonaceous material or asphaltite, such as the unit Kac, are also considered to be possible potential hosts for radioactive minerals. Further survey work is suggested for this area.

F. NATIONAL GAMMA RAY MAP SERIES (NGRMS)

The geologic base has been photographically screened to allow emphasis of the flight line locations and of the information regarding data analysis. These maps are used as the base for presenting statistical information on the six variables:

- * ^{208}Tl
- * ^{214}Bi
- * ^{40}K
- * $^{214}\text{Bi}/^{208}\text{Tl}$ Ratio
- * $^{214}\text{Bi}/^{40}\text{K}$ Ratio
- * $^{208}\text{Tl}/^{40}\text{K}$ Ratio

The six NGRMS sheets are presented in Figures IV. (1-6) of this report at a scale of 1:500,000 and as separate sheets at a scale of 1:250,000.

The statistical information is summarized on these maps through the utilization of one, two or three dots above or below the flight line at every fifth data point. One dot above the line indicates that the variable value at that point is between 1σ and 2σ greater than the mean value for that geologic type where σ values are determined for each geologic type based on all flight line data

from the area, as is discussed further in Section V.B.4. Two dots indicate values between 2σ and 3σ , and three dots show values greater than 3σ . Dots below the line indicate the variable values which are less than the mean value by 1, 2 or 3σ in the same manner.

G. LINE PRINTER CONTOURS

Printer contours have been generated at a 1:500,000 scale for seven variables ($e\text{Th}$, $c\text{U}$, K , $e\text{U}/e\text{Th}$, $e\text{U}/\text{K}$, $e\text{Th}/\text{K}$, and RMag , respectively). They appear in Appendix IV. Note that every alternate contour interval is composed of blanks to help delineate contour boundaries. Dots are used where the denominator value for a ratio is approaching zero, and to denote non-data areas.

GEODATA INTERNATIONAL, INC.
7035 JOHN W. CARPENTER FRWY. DALLAS, TEXAS 75247

NATIONAL GAMMA RAY MAP SERIES

San Antonio, Texas

200 T₁ ± STANDARD DEVIATIONS
REF. NTMS, NH 14-B
PREPARED FOR
U.S. DEPARTMENT OF ENERGY

IV-19a

"X" INDICATES FILM VERIFIED POINTS

Figure IV.1 National Gamma Ray Map Series

GEODATA INTERNATIONAL, INC.
7035 JOHN W. CARPENTER FRWY DALLAS, TEXAS 75247

NATIONAL GAMMA RAY MAP SERIES

San Antonio, Texas

214B ± STANDARD DEVIATIONS
REF N.T.M.S. NH 14-8
PREPARED FOR
U.S. DEPARTMENT OF ENERGY

IV-19b

"X" INDICATES FILM VERIFIED POINTS

Figure IV.2 National Gamma Ray Map Series

GEODATA INTERNATIONAL, INC.
7035 JOHN W. CARPENTERS HWY. DALLAS, TEXAS 75247

NATIONAL GAMMA RAY MAP SERIES

San Antonio, Texas

$40K \pm$ STANDARD DEVIATIONS
REF. NTMS, NH 14-8
PREPARED FOR
U.S. DEPARTMENT OF ENERGY

IV-19c

"X" INDICATES FILM VERIFIED POINTS

Figure IV.3 National Gamma Ray Map Series

GEODATA INTERNATIONAL, INC.
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NATIONAL GAMMA RAY MAP SERIES

San Antonio, Texas

214 Bi/208Tl ± STANDARD DEVIATIONS

REF. NIMS, NH 14-8
PREPARED FOR
U.S. DEPARTMENT OF ENERGY

IV-19d

"x" INDICATES FILM VERIFIED POINTS

Figure IV.4 National Gamma Ray Map Series

GFODATA INTERNATIONAL, INC.
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NATIONAL GAMMA RAY MAP SERIES

San Antonio, Texas

$214\text{Bi}/^{40}\text{K} \pm \text{STANDARD DEVIATIONS}$

REF. NTMS, NH 14-B
PREPARED FOR
U.S. DEPARTMENT OF ENERGY

IV-19e

"X" INDICATES FILM VERIFIED POINTS

Figure IV.5 National Gamma Ray Map Series

GEODATA INTERNATIONAL, INC.
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NATIONAL GAMMA RAY MAP SERIES

San Antonio, Texas

200T/40K ± STANDARD DEVIATIONS

REF. NTMS, NH 14-B
PREPARED FOR
U.S. DEPARTMENT OF ENERGY

IV-19f

"x" INDICATES FILM VERIFIED POINTS

Figure IV.6 National Gamma Ray Map Series

H. STACKED DATA PROFILES AND GEOLOGIC HISTOGRAMS

TL/K
3.5 /DIV

BI/K
1.2 /DIV

BI/TL
.09 /DIV

GC
400 C/S/DIV

RMAG
20 GAMMAS/DIV
BASE = -500.0

BIAIR
5.0 C/S/DIV

K
.25 PC/DIV

BI
.50 PPM/DIV

TL
1.5 PPM/DIV

ALT
100 FT/DIV

RMAG
10 GAMMA/DIV
BASE = -900.0

BMAG
10 GAMMA/DIV
BASE = 50000.0

BP
3 MM HG/DIV
BASE = 675.0

TEMP
1 DEG C/DIV
BASE = 10.0

ALT
100 FT/DIV

W ML | LONG 100.000 | LONG 99.500 | LONG 99.000 | LONG 98.500 | LONG 98.000

TL/K
3.5 /DIV

BI/K
1.2 /DIV

BI/TL
.09 /DIV

GC
400 C/S/DIV

RMAG
20 GAMMAS/DIV
BASE = -500.0

BIAIR
5.0 C/S/DIV

K
.25 PC/DIV

BI
.50 PPM/DIV

TL
1.5 PPM/DIV

ALT
100 FT/DIV

RMAG
10 GAMMA/DIV
BASE = -900.0

BMAG
10 GAMMA/DIV
BASE = 50000.0

BP
3 MM HG/DIV
BASE = 675.0

TEMP
1 DEG C/DIV
BASE = 10.0

ALT
100 FT/DIV

W ML LONG 100.000
40 SAN ANTONIO

TL/K
3.5 /DIV

BI/K
1.2 /DIV

BI/TL
.09 /DIV

GC
400 C/S/DIV

RMAG
20 GAMMAS/DIV
BASE = -500.0

BIAIR
5.0 C/S/DIV

K
.25 PC/DIV

BI
50 PPM/DIV

TL
1.5 PPM/DIV

ALT
100 FT/DIV

W | LONG 100.000 | LONG 99.750 | LONG 99.500 | LONG 99.250 | LONG 99.000 | LONG 98.750 | LONG 98.500 | LONG 98.250 | LONG 98.000

ML 60 SAN ANTONIO

RMAG
10 GAMMA/DIV
BASE = -900.0

BMAG
10 GAMMA/DIV
BASE = 5000.0

BP
3 MM HG/DIV
BASE = 675.0

TEMP
1 DEG C/DIV
BASE = 10.0

ALT
100 FT/DIV

W | LONG 100.000 | LONG 99.500 | LONG 99.000 | LONG 98.500 | LONG 98.000 E
ML 60 SAN ANTONIO

TL/K
3.5 /DIV

BI/K
1.2 /DIV

BI/TL
.03 /DIV

GC
400 C/S/DIV

RMAG
20 GAMMAS/DIV
BASE = -500.0

BIAIR
5.0 C/S/DIV

K
.25 PC/DIV

BI
.50 PPM/DIV

TL
1.5 PPM/DIV

ALT
100 FT/DIV

BMAG
10 GAMMA/DIV
BASE = 50000.0

BP
3 MM HG/DIV
BASE = 675.0

TEMP
1 DEG C/DIV
BASE = 10.0

ALT
100 FT/DIV

TL/K
3.5 /DIV

BI/K
1.2 /DIV

BI/TL
.09 /DIV

GC
400 C/S/DIV

RMAG
20 GAMMAS/DIV
BASE = -500.0

BIAIR
5.0 C/S/DIV

K
.25 PC/DIV

BI
.50 PPM/DIV

TL
1.5 PPM/DIV

ALT
100 FT/DIV

RMAG
10 GAMMA/DIV
BASE = -900.0

BMAG
10 GAMMA/DIV
BASE = 50000.0

BP
3 MM HG/DIV
BASE = 675.0

TEMP
1 DEG C/DIV
BASE = 10.0

ALT
100 FT/DIV

TL/K
3.5 /DIV

BI/K
1.2 /DIV

BI/TL
.09 /DIV

GC
400 C/S/DIV

RMAG
20 GAMMAS/DIV
BASE = -500.0

BIAIR
5.0 C/S/DIV

K
.25 PC/DIV

BI
.50 PPM/DIV

TL
1.5 PPM/DIV

ALT
100 FT/DIV

RMAG
10 GAMMA/DIV
BASE = -800.0

BMAG
10 GAMMA/DIV
BASE = 50000.0

BP
3 MM HG/DIV
BASE = 675.0

TEMP
1 DEG C/DIV
BASE = 10.0

ALT
100 FT/DIV

W | LONG 100.000 | LONG 99.500 | LONG 99.000 | LONG 98.500 | LONG 98.000 E
ML 140 SAN ANTONIO

TL/K
3.5 /DIV

BI/K
1.2 /DIV

BI/TL
.09 /DIV

GC
400 C/S/DIV

RMAG
20 GAMMAS/DIV
BASE = -500.0

BIAIR
5.0 C/S/DIV

K
.25 PC/DIV

BI
.50 PPM/DIV

TL
1.5 PPM/DIV

ALT
100 FT/DIV

RMAG
10 GAMMA/DIV
BASE = -900.0

BMAG
10 GAMMA/DIV
BASE = 50000.0

BP
3 MP HG/DIV
BASE = 675.0

TEMP
1 DEG C/DIV
BASE = 10.0

ALT
100 FT/DIV

TL/K
3.5 /DIV

BI/K
1.2 /DIV

BI/TL
.09 /DIV

GC
400 C/S/DIV

RMAG
20 GAMMAS/DIV
BASE = -500.0

BIAIR
5.0 C/S/DIV

K
.25 PC/DIV

BI
.50 PPM/DIV

TL
1.5 PPM/DIV

ALT
100 FT/DIV

W | LONG 100.000 | LONG 99.750 | LONG 99.500 | LONG 99.250 | LONG 99.000 | LONG 98.750 | LONG 98.500 | LONG 98.250 | LONG 98.000 E
ML 180 SAN ANTONIO

RMAG
10 GAMMA/DIV
BASE = -900.0

BMAG
10 GAMMA/DIV
BASE = 50000.0

BP
3 MM HG/DIV
BASE = 675.0

TEMP
1 DEG C/DIV
BASE = 10.0

ALT
100 FT/DIV

TL/K
3.5 /DIV

BI/K
1.2 /DIV

BI/TL
.03 /DIV

GC
400 C/S/DIV

RMAG
20 GAMMAS/DIV
BASE = -500.0

BIAIR
5.0 C/S/DIV

K
.25 PC/DIV

BI
.50 PPM/DIV

TL
1.5 PPM/DIV

ALT
100 FT/DIV

RMAG
10 GAMMA/DIV
BASE = -900.0

BMAG
10 GAMMA/DIV
BASE = 50000.0

BP
3 MM HG/DIV
BASE = 675.0

TEMP
1 DEG C/DIV
BASE = 10.0

ALT
100 FT/DIV

TL/K
3.5 /DIV

BI/K
1.2 /DIV

BI/TL
.09 /DIV

GC
400 C/S/DIV

RMAG
20 GAMMAS/DIV
BASE = -500.0

BIAIR
5.0 C/S/DIV

K
.25 PC/DIV

BI
.50 PPM/DIV

TL
1.5 PPM/DIV

ALT
100 FT/DIV

W | LONG 100.000 | LONG 99.750 | LONG 99.500 | LONG 99.250 | LONG 99.000 | LONG 98.750 | LONG 98.500 | LONG 98.250 | LONG 98.000 E
ML 220 SAN ANTONIO

RMAG
10 GAMMA/DIV
BASE = -900.0

BMAG
10 GAMMA/DIV
BASE = 50000.0

BP
3 MM HG/DIV
BASE = 675.0

TEMP
1 DEG C/DIV
BASE = 10.0

ALT
100 FT/DIV

TL/K
3.5 /DIV

BI/K
1.2 /DIV

BI/TL
.09 /DIV

GC
400 C/S/DIV

RMAG
20 GAMMAS/DIV
BASE = -500.0

BIAIR
5.0 C/S/DIV

K
.25 PC/DIV

BI
.50 PPM/DIV

TL
1.5 PPM/DIV

ALT
100 FT/DIV

ML 240 SAN ANTONIO

RMAG
10 GAMMA/DIV
BASE = -900.0

BMAG
10 GAMMA/DIV
BASE = 50000.0

BP
3 MM HG/DIV
BASE = 675.0

TEMP
1 DEG C/DIV
BASE = 10.0

ALT
100 FT/DIV

TL/K
3.5 /DIV

BI/K
1.2 /DIV

BI/TL
.09 /DIV

GC
400 C/S/DIV

RMAG
20 GAMMAS/DIV
BASE = -500.0

BIAIR
5.0 C/S/DIV

K
.25 PC/DIV

BI
.50 PPM/DIV

TL
1.5 PPM/DIV

ALT
100 FT/DIV

RMAG
10 GAMMA/DIV
BASE = -300.0

BMAG
10 GAMMA/DIV
BASE = 50000.0

BP
3 MM HG/DIV
BASE = 675.0

TEMP
1 DEG C/DIV
BASE = 10.0

ALT
100 FT/DIV

TL/K
3.5 /DIV

BI/K
1.2 /DIV

BI/TL
.09 /DIV

GC
400 C/S/DIV

RMAG
20 GAMMAS/DIV
BASE = -500.0

BIAIR
5.0 C/S/DIV

K
.25 PC/DIV

BI
.50 PPM/DIV

TL
1.5 PPM/DIV

ALT
100 FT/DIV

RMAG
10 GAMMA/DIV
BASE = -900.0

BMAG
10 GAMMA/DIV
BASE = 50000.0

BP
3 MM HG/DIV
BASE = 675.0

TEMP
1 DEG C/DIV
BASE = 10.0

ALT
100 FT/DIV

RMAG
10 GAMMA/DIV
BASE = -900.0

BMAG
10 GAMMA/DIV
BASE = 50000.0

BP
3 MM HG/DIV
BASE = 675.0

TEMP
1 DEG C/DIV
BASE = 10.0

ALT
100 FT/DIV

TL/K
3.5 /DIV

BI/K
1.2 /DIV

BI/TL
.09 /DIV

GC
400 C/S/DIV

RMAG
20 GAMMAS/DIV
BASE = -500.0

BIAIR
5.0 C/S/DIV

K
.25 PC/DIV

BI
.50 PPH/DIV

TL
1.5 PPH/DIV

ALT
100 FT/DIV

TL/K
3.5 /DIV

BI/K
1.2 /DIV

BI/TL
.09 /DIV

GC
400 C/S/DIV

RMAG
20 GAMMAS/DIV
BASE = -500.0

BIAIR
5.0 C/S/DIV

K
.25 PC/DIV

BI
.50 PPM/DIV

TL
1.5 PPM/DIV

ALT
100 FT/DIV

W | LONG 100.000 | LONG 99.750 | LONG 99.500 | LONG 99.250 | LONG 99.000 | LONG 98.750 | LONG 98.500 | LONG 98.250 | LONG 98.000

TL/K
3.5 /DIV

BI/K
1.2 /DIV

BI/TL
.09 /DIV

GC
400 C/S/DIV

RMAG
20 GAMMAS/DIV
BASE = -500.0

BIAIR
5.0 C/S/DIV

K
.25 PC/DIV

BI
.50 PPM/DIV

TL
1.5 PPM/DIV

ALT
100 FT/DIV

RMAG
10 GAMMA/DIV
BASE = -900.0

BMAG
10 GAMMA/DIV
BASE = 50000.0

BP
3 MM HG/DIV
BASE = 675.0

TEMP
1 DEG C/DIV
BASE = 10.0

ALT
100 FT/DIV

W | LONG 100.000 | LONG 99.500 | LONG 99.000 | LONG 98.500 | LONG 98.000 E
ML 360 SAN ANTONIO

TL/K
3.5 /DIV

BI/K
1.2 /DIV

BI/TL
.09 /DIV

GC
400 C/S/DIV

RMAG
20 GAMMAS/DIV
BASE = -500.0

BIAIR
5.0 C/S/DIV

K
.25 PC/DIV

BI
.50 PPH/DIV

TL
1.5 PPH/DIV

ALT
100 FT/DIV

W ML 300 | LONG 100.000 | LONG 99.750 | LONG 99.500 | LONG 99.250 | LONG 99.000 | LONG 98.750 | LONG 98.500 | LONG 98.250 | LONG 98.000E

RMAG
10 GAMMA/DIV
BASE = 900.0

BMAG
10 GAMMA/DIV
BASE = 50000.0

BP
3 MM HG/DIV
BASE = 675.0

TEMP
1 DEG C/DIV
BASE = 10.0

ALT
100 FT/DIV

RMAG
10 GAMMA/DIV
BASE = -900.0

BMAG
10 GAMMA/DIV
BASE = 50000.0

BP
3 MM HG/DIV
BASE = 675.0

TEMP
1 DEG C/DIV
BASE = 10.0

ALT
100 FT/DIV

TL/K
3.5 /DIV

BI/K
1.2 /DIV

BI/TL
.03 /DIV

GC
400 C/S/DIV

RMAG
20 GAMMAS/DIV
BASE = -500.0

BIAIR
5.0 C/S/DIV

K
.25 PC/DIV

BI
.50 PPM/DIV

TL
1.5 PPM/DIV

ALT
100 FT/DIV

TL/K
3.5 /DIV

BI/K
1.2 /DIV

BI/TL
.03 /DIV

GC
400 C/S/DIV

RMAG
20 GAMMAS/DIV
BASE = -500.0

BIAIR
5.0 C/S/DIV

K
.25 PC/DIV

BI
.50 PPM/DIV

TL
1.5 PPM/DIV

ALT
100 FT/DIV

W | LONG 100.000 | LONG 99.500 | LONG 99.000 | LONG 98.500 | LONG 98.000 |
ML 440 SAN ANTONIO

RMAG
10 GAMMA/DIV
BASE = -800.0

BMAG
10 GAMMA/DIV
BASE = 50000.0

BP
3 MM HG/DIV
BASE = 675.0

TEMP
1 DEG C/DIV
BASE = 10.0

ALT
100 FT/DIV

TL/K
3.5 /DIV

BI/K
1.2 /DIV

BI/TL
.09 /DIV

GC
400 C/S/DIV

RMAG
20 GAMMAS/DIV
BASE = -500.0

BIAIR
5.0 C/S/DIV

K
.25 PC/DIV

BI
.50 PPM/DIV

TL
1.5 PPM/DIV

ALT
100 FT/DIV

RMAG
10 GAMMA/DIV
BASE = -800.0

BMAG
10 GAMMA/DIV
BASE = 50000.0

BP
3 MM HG/DIV
BASE = 675.0

TEMP
1 DEG C/DIV
BASE = 10.0

ALT
100 FT/DIV

TL/K
3.5 /DIV

BI/K
1.2 /DIV

BI/TL
.09 /DIV

GC
400 C/S/DIV

RMAG
20 GAMMAS/DIV
BASE = -500.0

BIAIR
5.0 C/S/DIV

K
.25 PC/DIV

BI
.50 PPM/DIV

TL
1.5 PPM/DIV

ALT
100 FT/DIV

S | LAT 29.000 | LAT 29.500 | LAT 30.000 N
TL 5040 SAN ANTONIO

RMAG
10 GAMMA/DIV
BASE = -800.0

BMAG
10 GAMMA/DIV
BASE = 50000.0

BP
3 MM HG/DIV
BASE = 675.0

TEMP
1 DEG C/DIV
BASE = 10.0

ALT
100 FT/DIV

TL/K
3.5 /DIV

BI/K
1.2 /DIV

BI/TL
.09 /DIV

GC
400 C/S/DIV

RMAG
20 GAMMAS/DIV
BASE = -500.0

BIAIR
5.0 C/S/DIV

K
.25 PC/DIV

BI
.50 PPM/DIV

TL
1.5 PPM/DIV

ALT
100 FT/DIV

S | LAT 29.000 | LAT 29.500 | LAT 30.000 N
TL 5060 SAN ANTONIO

RMAG
10 GAMMA/DIV
BASE = -900.0

BMAG
10 GAMMA/DIV
BASE = 50000.0

BP
3 MM HG/DIV
BASE = 675.0

TEMP
1 DEG C/DIV
BASE = 10.0

ALT
100 FT/DIV

TL/K
3.5 /DIV

BI/K
1.2 /DIV

BI/TL
.09 /DIV

GC
400 C/S/DIV

RMAG
20 GAMMAS/DIV
BASE = -500.0

BIAIR
5.0 C/S/DIV

K
.25 PC/DIV

BI
.50 PPM/DIV

TL
1.5 PPM/DIV

ALT
100 FT/DIV

RMAG
10 GAMMA/DIV
BASE = -800.0

BMAG
10 GAMMA/DIV
BASE = 50000.0

BP
3 MM HG/DIV
BASE = 675.0

TEMP
1 DEG C/DIV
BASE = 10.0

ALT
100 FT/DIV

TL/K
3.5 /DIV

BI/K
1.2 /DIV

BI/TL
.09 /DIV

GC
400 C/S/DIV

RMAG
20 GAMMAS/DIV
BASE = -500.0

BIAIR
5.0 C/S/DIV

K
.25 PC/DIV

BI
.50 PPM/DIV

TL
1.5 PPM/DIV

ALT
100 FT/DIV

RMAG
10 GAMMA/DIV
BASE = -800.0

BMAG
10 GAMMA/DIV
BASE = 50000.0

BP
3 MM HG/DIV
BASE = 675.0

TEMP
1 DEG C/DIV
BASE = 10.0

ALT
100 FT/DIV

TL/K
3.5 /DIV

BI/K
1.2 /DIV

BI/TL
.09 /DIV

GC
400 C/S/DIV

RMAG
20 GAMMAS/DIV
BASE = -500.0

BIAIR
5.0 C/S/DIV

K
.25 PC/DIV

BI
.50 PPM/DIV

TL
1.5 PPM/DIV

ALT
100 FT/DIV

RMAG
10 GAMMA/DIV
BASE = -800.0

BMAG
10 GAMMA/DIV
BASE = 50000.0

BP
3 MM HG/DIV
BASE = 675.0

TEMP
1 DEG C/DIV
BASE = 10.0

ALT
100 FT/DIV

S | LAT 29.000 | LAT 29.500 | LAT 30.000 N
TL 5120 SAN ANTONIO

TL/K
3.5 /DIV

BI/K
1.2 /DIV

BI/TL
.09 /DIV

GC
400 C/S/DIV

RMAG
20 GAMMAS/DIV
BASE = -500.0

BIAIR
5.0 C/S/DIV

K
.25 PC/DIV

BI
.50 PPM/DIV

TL
1.5 PPM/DIV

ALT
100 FT/DIV

S | LAT 29.000 | LAT 29.500 | LAT 30.000 N
TL 5140 SAN ANTONIO

RMAG
10 GAMMA/DIV
BASE = -200.0

BMAG
10 GAMMA/DIV
BASE = 50000.0

BP
3 MM HG/DIV
BASE = 675.0

TEMP
1 DEGREE C/DIV
BASE = 10.0

ALT
100 FT/DIV

TL/K
3.5 /DIV

BI/K
1.2 /DIV

BI/TL
.03 /DIV

GC
400 C/S/DIV

RMAG
20 GAMMAS/DIV
BASE = -500.0

BIAIR
5.0 C/S/DIV

K
.25 PC/DIV

BI
.50 PPM/DIV

TL
1.5 PPM/DIV

ALT
100 FT/DIV

RMAG
10 GAMMA/DIV
BASE = -800.0

BMAG
10 GAMMA/DIV
BASE = 50000.0

BP
3 MM HG/DIV
BASE = 675.0

TEMP
1 DEG C/DIV
BASE = 10.0

ALT
100 FT/DIV

TL/K
3.5 /DIV

BI/K
1.2 /DIV

BI/TL
.03 /DIV

GC
400 C/S/DIV

RMAG
20 GAMMAS/DIV
BASE = -500.0

BIAIR
5.0 C/S/DIV

K
.25 PC/DIV

BI
.50 PPM/DIV

TL
1.5 PPM/DIV

ALT
100 FT/DIV

S | TL 5100 SAN ANTONIO | LAT 23.500 | LAT 30.000 N

RMAG
10 GAMMA/DIV
BASE = -900.0

BMAG
10 GAMMA/DIV
BASE = 50000.0

BP
3 MM HG/DIV
BASE = 675.0

TEMP
1 DEG C/DIV
BASE = 10.0

ALT
100 FT/DIV

TL 5180 SAN ANTONIO

LAT 29.500

LAT 30.000 N

TL/K
3.5 /DIV

BI/K
1.2 /DIV

BI/TL
.09 /DIV

GC
400 C/S/DIV

RMAG
20 GAMMAS/DIV
BASE = -500.0

BIAIR
5.0 C/S/DIV

K
.25 PC/DIV

BI
.50 PPM/DIV

TL
1.5 PPM/DIV

ALT
100 FT/DIV

RMAG
10 GAMMA/DIV
BASE = -900.0

BMAG
10 GAMMA/DIV
BASE = 50000.0

BP
3 MM HG/DIV
BASE = 675.0

TEMP
1 DEG C/DIV
BASE = 10.0

ALT
100 FT/DIV

SAN ANTONIO

NO. OF EVENTS

JNCNINE NES

NO. OF EVENTS

A 5

A 6

SAN ANTONIO

A 7

SAN ANTONIO

A 8

SAN ANTONIO

SAN ANTONIO

SAN ANTONIO

SAN ANTONIO

SAN ANTONIO

A 13

SAN ANTONIO

A 14

SAN ANTONIO

A 15

SAN ANTONIO

A 16

SAN ANTONIO

SAN ANTONIO

SAN ANTONIO

SAN ANTONIO

NO. OF EVENTS

NO. OF EVENTS

SAN ANTONIO

SAN ANTONIO

SECTION V

GEODATA DATA AQUISITION AND PROCESSING

V-2

V-3

The nine-crystal detector array has been calibrated to measure the gamma radiation spectrum between 0-6 MeV. The contents of the 3 to 6 MeV interval is monitored in order to reduce the contributions of the cosmic events in the 0-3 MeV interval, which is of primary interest in this survey. Eight of the nine detectors are mounted to measure the 4π solid angle gamma radiation spectrum emanating from the earth's surface. The ninth detector, which is partially shielded underneath by a 3.5-inch lead plate, is situated to measure the ^{214}Bi radiation incoming from the upper 2π solid angle.

The energy resolution of the GDAS as calculated from the ^{137}Cs 662 keV photopeak was 10.7%, where each individual crystal was 9.0% or better. Automatic digital gain calibration for the eight detector array and the single detector system was accomplished by stabilizing on the ^{40}K photopeak data.

The diagram illustrates the architecture of the Data General Nova computer system, centered around a **DATA GENERAL NOVA COMPUTER**. The system is divided into several functional sections:

- Input Section:**
 - DTIC TORS** provides eight channels (1-8) to a **LINEAR MIXER (2)**.
 - Channels 1-4 are labeled **PA-1** through **PA-4**.
 - Channels 5-8 are labeled **PA-5** through **PA-8**.
 - A **2" SHIELD** is connected to the mixer.
 - REL. ALT. LEAD PRESS** and **A-D C/S MUX** are connected to the **ADC CONTROLLER**.
- Processing Section:**
 - The **ADC CONTROLLER** feeds into the **DATA GENERAL NOVA COMPUTER**.
 - The computer outputs to **PHA #1** and **PHA #2** controllers.
 - PHA #1** controls **LIVE TIME #1** and **DIGITAL STABILIZER**.
 - PHA #2** controls **LIVE TIME #2** and **DIGITAL STABILIZER**.
 - LIVE TIME #1** and **LIVE TIME #2** feed into a **512/8192 CH** block.
 - The **512/8192 CH** block feeds into a **LINEAR AMPL. (2)**.
 - The **LINEAR AMPL. (2)** feeds into a **LINEAR AMPLIFIER**.
- Output Section:**
 - The **LINEAR AMPLIFIER** feeds into a **MAGNETOMETER**.
 - The **MAGNETOMETER** outputs **X** and **Y** coordinates to a **DOPPLER CONTROLLER**.
 - The **DOPPLER CONTROLLER** feeds into a **MAG CONTROLLER**.
 - The **MAG CONTROLLER** feeds into the **DATA GENERAL NOVA COMPUTER**.
 - The **DATA GENERAL NOVA COMPUTER** also feeds into a **GRAPHIC DISPLAY CONTROLLER**.
 - The **GRAPHIC DISPLAY CONTROLLER** feeds into a **D-A C/MUX**.
 - The **D-A C/MUX** feeds into an **ANALOG RECORDER**.
 - The **DATA GENERAL NOVA COMPUTER** also feeds into a **COCKPIT DISPLAY** and an **OPERATOR DISPLAY**.
 - The **COCKPIT DISPLAY** and **OPERATOR DISPLAY** feed into a **VISUAL DISPLAY CONTROLLER**.
 - The **VISUAL DISPLAY CONTROLLER** feeds into a **CAMERA CONTROL**.
 - The **CAMERA CONTROL** feeds into a **CAMERA**.
- Storage Section:**
 - The **DATA GENERAL NOVA COMPUTER** is connected to two **MAGNETIC TAPE CONTROLLER** units.
 - Each **MAGNETIC TAPE CONTROLLER** is connected to a **DIGI-DATA 1507-556 MAGNETIC TAPE UNIT**.
 - The **DATA GENERAL NOVA COMPUTER** is also connected to an **ASR-33 TELETYPEWRITER**.

Figure V.1 Survey Aircraft

Figure V.2 System Block Diagram

Digital-to-analog conversion of the resultant intensities, their ratios and the magnetic field data are plotted on multi-track paper, allowing immediate examination for anomalous data.

The spectral data from the single detector system gathers and records the 2 π spectral data every nine seconds. This 2 π data is necessary to determine the amount of atmospheric ²¹⁴Bi radiation in the 4 π spectral data. A third segment of the computer's core gathers and sums the total 2 π and 4 π gamma radiation spectra for each flight line, which can then be plotted as shown in Figure V.3 (EOFL spectrum).

Due to the dependence of the gamma ray data on altitude, a highly accurate radar altimeter is used. The Collins ALT-50 system is designed to make a series of 8 measurements per second, where the resulting altitude is the average.

Since the gathered data are dependent on the current ambient temperature and pressure readings, a Senso-Tek barometric pressure sensor and a Hy-Col thermocouple sensor were used to monitor conditions outside the aircraft.

A proton precession magnetometer sensor, having a 0.25 gamma readout resolution and less than a 1.0 gamma noise envelope, is sampled every second to yield a measurement of the total intensity of the earth's magnetic field below the aircraft. The sensor is carried as a "bird" on a 100-foot cable in order to minimize the magnetic effects of the aircraft.

A Bendix DRA-12C navigation system with a ± 100 th/nautical mile accuracy provides a doppler navigation cross-track and along-track analog signal to be recorded each second onto magnetic tape. Two other methods are used to properly locate the aircraft's track: visual sightings and photography. The first method is employed by the navigator who marks flight map location reference points with computer-displayed record numbers. The second method is a 35mm film that records a continuous, recoverable track which has a 20% overlap/frame at an elevation of 400 feet.

There are three basic operating modes of the GDAS that the operator can manipulate:

- 1) CALIBRATE, which allows proper gain calibration for the detectors;
- 2) OPERATE, which allows data to be collected, summed and recorded; and
- 3) PLAYBACK, which allows the operator to examine the newly acquired data.

Figure V.3 Typical End-of-Flight-Line Spectral Plot

B. DATA PROCESSING

1. Data Reduction

The field data tapes produced by the data acquisition system (Section V.A) contain the 4 π and 2 π gamma radiation spectra, measured between 0 to 6 MeV. The resulting gamma ray spectra are composite spectra of the several different isotopes that emit gamma rays within the detectors' energy range. The method used in this work to determine the concentrations of the different isotopes monitored is discussed in this section.

In this work, there are four different isotopes which contributed to the resultant composite spectra under consideration. In order of the highest to lowest energy emitter, they are: cosmic, eTh, eU and K counting rates.

Isotope	Energy Interval (MeV)
Cosmic	3.0 to 6.0
²⁰⁸ Tl	2.410 to 2.796
²¹⁴ Bi	1.661 to 1.860
⁴⁰ K	1.357 to 1.556

Due to the occurrence of Compton scatter at all gamma ray energy intervals, a 4 x 4 matrix method approach is used to "spectrally strip" the group summed counting rates into their individual counting rates attributed only to the isotope associated with that energy interval.

This matrix method approach is theoretically applicable to a spectrum containing any number of isotopic gamma rays. For convenience, the four isotopes will be denoted as: COS, TL, BI and K. The channel group sum for each energy interval can be considered to consist of fractional components of each of its constituents. For instance, one can write for the TL channel group sum:

$$a_{COS} + 1.0TL + f_{BI} + 0.0K = MTL$$

where MTL is the channel group sum count;

and the coefficients, which are known as Compton coefficients, for each variable represent the responses of the data gathering system to each isotope over the entire energy spectrum.

Similarly, equations can be written for the energy interval group sums for MCOS, MBI and MK, as shown below in matrix notation by

$$\begin{bmatrix} 1.0 & 0.0 & 0.0 & 0.0 \\ a & 1.0 & f & 0.0 \\ b & \alpha & 1.0 & g \\ c & \beta & \gamma & 1.0 \end{bmatrix} \begin{bmatrix} \text{COS} \\ \text{TL} \\ \text{BI} \\ \text{K} \end{bmatrix} = \begin{bmatrix} \text{MCOS} \\ \text{MTL} \\ \text{MBI} \\ \text{MK} \end{bmatrix}$$

where each element of the 4 x 4 matrix is a Compton coefficient. By inverting the 4 x 4 matrix and multiplying on the left by the channel group sum matrix, the resulting column matrix, whose elements are COS, TL, BI, and K, represents the counts in each energy interval attributed only to the indicated isotope source.

Table V.1 contains the data reduction parameters, coefficients and backgrounds used in this survey. The listed Compton coefficients were determined from data acquired during high altitude flights and from "known" test pad data concentrations in Grand Junction, Colorado.

The resulting reduced counting rates for COS, TL, BI and K must then be normalized with respect to the measured live time counting rate of the data acquisition system. This is necessary in order to restore the linear relationship between the photopeak counts and the source's intensity. This procedure is accomplished by dividing the reduced counts by the live time, LTC1:

thus,

$$\begin{array}{lcl} \text{COS1} & = & \text{COS/LTC1} \\ \text{TL1} & = & \text{TL/LTC1} \\ \text{BI1} & = & \text{BI/LTC1} \\ \text{K1} & = & \text{K/LTC1} \end{array}$$

The next step in the data processing involves the subtraction of the background counts present onboard the aircraft. The background counts, which exist in the aircraft and its equipment, are determined from high altitude data where the data acquisition is free from all ground sources and atmospheric ^{214}Bi contamination. The background counts, denoted as B_{TL} , B_{BI} and B_K , used in this work are listed in Table V.1. During the processing, the backgrounds are checked by observing the resulting counting rates over large bodies of water, where the rates would have near zero intensities. The gross count's background counting rate, B_{GC} , over channels 35-239, is also given in Table V.1.

After the backgrounds have been subtracted from the live time corrected photopeak counts, thus

$$\begin{array}{lcl} \overline{\text{TLI}} & = & \text{TL1} - B_{TL} \\ \overline{\text{BII}} & = & \text{BI1} - B_{BI} \\ \overline{\text{KI}} & = & \text{K1} - B_K \end{array}$$

The resulting counting rates for $\overline{\text{TLI}}$ and $\overline{\text{KI}}$ represent the counts contributed only by the sources below the aircraft on the earth's surface. In the case of $\overline{\text{BII}}$, an additional source of ^{214}Bi radiation, which is caused by atmospheric ^{214}Bi , BIAIR, is still eminent.

The 2π detector system data is used to determine the magnitude of the BIAIR to be subtracted. Since the predominate variable source affecting the 2π detector is the atmospheric ^{214}Bi , it is possible to utilize most of the 2π spectrum in the BIAIR determination, and thereby produce some improvement in the statistical error. The energy interval used for the 2π crystal is between 1.05 to 2.79 MeV. Within this interval, the aircraft's background, $B_{2\pi}$, and its Compton coefficient, $C_{2\pi}$, have been determined from the high altitude data. (See Table V.1).

The BIAIR associated with the unshielded detector array is determined, using the shielded detector by the relation:

$$\text{BIAIR} = \frac{G(x)}{(1 - k_2 G(x))} [VC - C_{2\pi} \cdot \text{COS1} - b_{2\pi} - \text{RVALM}]$$

where

$G(x)$ is the relationship between the 4π and 2π solid angles, the channel group sums and the number of detectors in the detector arrays;

VC is the 2π total count group sum of channels 91-239, c/s;

COS1 is the 4π cosmic count, greater than 3.0 MeV, c/s;

and,

$$\text{RVALM} = k_1 \overline{\text{TLI}} + k_2 \overline{\text{BII}} + k_3 \overline{\text{KI}}$$

where k_1 , k_2 , k_3 are constant factors that correct for the penetration/spill of the emanated surface radiation. These penetration/spill constants are dependent on the amount of lead shielding used on the 2π crystal. The values used in this work are listed in Table V.1.

$\overline{\text{TLI}}$, $\overline{\text{BII}}$ and $\overline{\text{KI}}$ have already been defined as the 4π reduced data counting rates, c/s.

Finally, the ^{214}Bi counting rate caused only by the surface sources is given by

$$\text{BISUR} = \overline{\text{BII}} - \text{BIAIR}$$

Briefly summarizing, $\overline{\text{TLI}}$, BISUR and $\overline{\text{KI}}$ are the counting rates as measured at the height of the aircraft. All interfering counts from cosmic, backgrounds and atmospheric ^{214}Bi have been removed.

Since the various counting rates are dependent upon the height of the aircraft above the surface terrain, it is necessary to correct the associated isotope's counting rate to an altitude of 400 feet above the surface terrain. This is accomplished through the equations indicated below:

$$\text{TLS} = \overline{\text{TLI}} \cdot e^{-\mu_1(400 - \frac{\rho}{\rho_0} x)}$$

$$\text{BIS} = \text{BISUR} \cdot e^{-\mu_2(400 - \frac{\rho}{\rho_0} x)}$$

$$\text{KS} = \overline{\text{KI}} \cdot e^{-\mu_3(400 - \frac{\rho}{\rho_0} x)}$$

and

$$\text{GC(gross count)} = (\overline{\text{GC}} - B_{GC} - S \cdot \text{BIAIR}) \cdot e^{-\mu_4(400 - \frac{\rho}{\rho_0} x)}$$

where

$\overline{\text{GC}}$ is the live time corrected gross count, channels 35-239,

S is the ratio of the BI data, channels 35-239 to channels 143-159,

B_{GC} is the gross count background,

TLS,BIS,KS are the respective photopeak's counting rates at 400 feet;

ρ_0 is the air density at standard temperature and pressure; 0.001293 gm/cc

ρ is the air density at the time the survey data was flown;

$\mu_1, \mu_2, \mu_3, \mu_4$ are the respective linear attenuation coefficients;

x is the aircraft's height above the surface terrain in feet.

The attenuation coefficients and other constants used in the altitude normalization are listed in Table V.1.

After each flight line of data has undergone the above data reduction, the average values for each radiation variable and variable ratios for each of the flight lines were plotted to demonstrate the consistency of the average values and that a smooth flow continues from day to day, and from the start to the finish of each day.

Diurnal variations of the magnetic field base station intensity were measured and applied to the field data. (See Section II.D and Appendix I.C). The magnetic heading corrections for the aircraft and its equipment used in this survey were determined by flying a predetermined path at a survey altitude in first an east to west direction, then in a west to east direction. The same procedure is used on a north to south path. Based on the data obtained in this fashion, see Table V.1, the heading corrections were removed from all the data. The magnetic field data were then IGRF corrected to give the residual magnetic field. The International Geomagnetic Reference Field subtracted was provided by the U.S. Geological Survey with reference to the IAGA Bulletin #38, "Grid Values and Charts by the IGRF 1975.0", National Technical Information Service Report #PB265483.

The system sensitivities at 400 feet used in this survey are shown in Table V.1.

2. Description of the Data Processing

The processing flow chart representative of the work performed in this survey is shown in Figure V.4.

As stated in Section V.A., the original field data tapes were recorded to contain the various tag words, 4 π and 2 π spectral

TABLE V-1: DATA REDUCTION PARAMETERS AND CONSTANTS - N540S - 1980

AIRCRAFT BACKGROUNDS				COSMIC CORRECTION RATIOS	
Detector	Parameter	Window	Value (CPS)	Parameter	Value
Terrestrial (4 π)	B _K	Potassium	29.98	c	0.2069
	B _{Di}	Uranium	9.40	b	0.1651
	B _{Tl}	Thorium	5.83	a	0.2202
	B _{GC}	Gross	286.69	-	-
Atmospheric (2 π)	B _{2π}	Uranium	8.33	C _{2π}	0.2232

DERIVED STRIPPING COEFFICIENTS AND RATIOS			
Coefficient	Value	Coefficient	Value
α	0.2755	k ₁	0.030
β	0.4058	k ₂	0.0
γ	0.8595	k ₃	0.0
f	0.0693	S	17.5
g	0.0156	-	-

LINEAR ABSORPTION COEFFICIENTS			MAGNETIC HEADING CORRECTION	
Radio Element	Parameter	Value (x10 ⁻³ per ft.)	Flight Direction	Correction (gammas)
Potassium	μ_1	2.448	West to East	+3.56
Uranium	μ_2	1.329	East to West	-3.56
Thorium	μ_3	1.899	North to South	-1.0
Gross	μ_4	1.430	South to North	+1.0

RADIOELEMENT	SYSTEM SENSITIVITIES AT 400 FEET
Potassium (cps/%K)	98.06
Uranium (cps/ppm eU)	13.52
Thorium (cps/ppm eTh)	7.15

V-11

Figure V.4 Data Reduction Flow Chart

V-12

V-10

data and the trailer record sums for each flight line. The purpose of the REFORM program is to sum the raw spectral data (LDT) into the proper group sum energy intervals for each second for each line. The CDTPLT program is a data certification program that produces the EOFL spectral plots, Figure V.3, and profiles of each of the channel group sums, which are plotted as a function of each line's record numbers.

A brief summary of each program and its uses is given below:

PROGRAM	FUNCTION
REFORM	Produces energy group sums and EOFL spectra.
FIXMOD	Primary processing for "spectral stripping" matrix reduction, live time normalization, background and BIAIR subtraction, and altitude corrections.
STACK	Flight path recovery to produce record location map at a scale of 1:250,000.
DOPTAP	Single record processing with latitude/longitude positioning, IGRF and single point statistical adequacy computations, and magnetic heading corrections.
GNDMRG	Merges aircraft magnetometer and ground magnetometer in proper time sequence and applies diurnal corrections to the field data.
VARPLT	Produces radiometric and magnetic stacked profile plot tapes.
HISTO,MERGE, and SORT1	Preliminary programs to prepare/sort data as a function of geologic type for the entire area.
HISPLT	Produces geological histograms, mean and standard deviation tables, and plot tape for the entire area.
GEODOT	Produces plot tape for standard deviation "dot plots" related to geologic type.
FICHE	Produces average record and single record reduced data listings and microfiche tapes, which are sent to microfiche vendor.
CUSTOMER	Produces all customer required tapes.

3. Data Presentation

The surveyed area was positioned geographically to completely cover the specific National Topographic Map. Each topographic map has been used as the flight base and sufficient geographical and 15' location information has been shown. The flight line pattern has been superpositioned onto these created base maps, where the standard deviation levels for each independent variable and each ratio of these variables have been plotted (NGRMS), based on the data contained within the total map area. Every fifth data point along each map line has its standard deviation value shown at the location of that value. Therefore, there are six NGRMS sheets which indicate the location and magnitude of anomalous data.

The multivariable map line profile, which represents 10 variables as a function of their latitude and longitude location for each line, is presented at a scale of 1:500,000. Each profile presents:

1. Aircraft altitude above the surface
2. eTh (^{208}Tl from ^{232}Th decay series)
3. eU (^{214}Bi from ^{238}U decay series)
4. K (^{40}K from natural potassium)
5. BIAIR (atmospheric ^{214}Bi)
6. Residual magnetic field
7. Gross count (greater than 400 keV)
8. eU/eTh ($^{214}\text{Bi}/^{208}\text{Tl}$) ratio
9. eU/K ($^{214}\text{Bi}/^{40}\text{K}$) ratio
10. eTh/K ($^{208}\text{Tl}/^{40}\text{K}$) ratio
11. Geologic data, including aircraft flight path

The residual magnetic field map line profile, which represents five variables as a function of their latitude and longitude location for each line, plus geologic data at a scale of 1:500,000 is presented as:

1. Aircraft altitude
2. Atmospheric temperature
3. Atmospheric pressure
4. Residual magnetic field data
5. Magnetic field base line station data
6. Geological data, including aircraft flight path

The output of these various computations supplies, beyond two profile sets, the following data:

- * Histograms of the radiation data distribution within each geologic unit.

- * Histograms of the average velocity distribution for each one-second record for each map and tie line.
- * Histograms of the average altitude distribution for each one-second record for each map and tie line.
- * Tables giving the average radiation concentration of each geologic unit for each flight line.
- * Average radiation concentration for each variable as a function of flight line, including the atmospheric ^{214}Bi .
- * Set of maps showing the standard deviation data as a function of location and radiation variable.
- * Printer plot contour maps of eTh, eU, K, eU/K, eU/eTh, eTh/K and the magnetics at a scale of 1:500,000.

4. Statistical Analysis Procedures

It is necessary to exclude from the statistical analysis all variables which have too low a counting rate to be statistically valid, and data which were obtained at altitudes above 1,000 feet. To this end, a statistical adequacy test was run on all data for each data record. If a given value of Tl, Bi or K failed the test, that variable value, and any ratio value associated with it, were not used in the statistical determinations of mean and standard deviation values. In addition, such values are indicated on the radiometric profiles by a vertical (tick) mark along the base line for the variable, and are flagged in the single record and averaged record listings (microfiche). The ratio values are set to zero in the Radiometric Profile Plots. The flags in the listings appear under the heading AKUT for altitude, ^{40}K , ^{214}Bi and ^{208}Tl , respectively. The flags are zero for statistically valid data, and one for rejected data in the case of K, U and T. For altitude (A), a zero indicates altitudes to 700 feet, a one (1) indicates altitudes between 700 and 1,000 feet, and a two (2) indicates altitudes above 1,000 feet.

The tests used to reject data were as follows:

$$\begin{array}{llll} (1) \text{ T}\bar{\text{L}}\text{I} < 1.5 & \sqrt{\frac{\text{T}\bar{\text{L}}\text{W} - \text{T}\bar{\text{L}}\text{I}}{}} & = & 1.5\sigma\text{T} \\ (2) \text{ B}\bar{\text{I}}\text{S}\bar{\text{U}}\text{R} < 1.5 & \sqrt{\frac{\text{B}\bar{\text{I}}\text{W} - \text{B}\bar{\text{I}}\text{S}\bar{\text{U}}\text{R}}{}} & = & 1.5\sigma\text{B} \\ (3) \text{ K}\bar{\text{I}} < 1.5 & \sqrt{\frac{\text{K}\bar{\text{W}} - \text{K}\bar{\text{I}}}{}} & = & 1.5\sigma\text{K} \end{array}$$

where the "w" subscript refers to the respective window counting rates from the raw data and $\overline{TQI}$, BISUR and $\overline{KI}$ have previously been defined. If any of the above inequalities were true, the associated variable was flagged, and that value was rejected in all statistical determinations.

The values of the radicals in the above equations, which are indicated as σI , σB , σK and the barred values, were calculated on the basis of a single record value for determining flags in the single record listings and the 7-point weighted values for determining flags in the averaged records listings.

The mean value and standard deviations were calculated assuming the data to have a normal distribution within a geologic type. The equation used in determining the variance is:

$$\sigma^2 = \frac{1}{N-1} \left\{ \sum_{i=1}^N x_i^2 - N\overline{x}^2 \right\}$$

where N is the number of statistically valid samples for a given geologic type, x_i is the value of the variable for sample number i, and $\overline{x}$ is the mean value of the variable for the geologic type. Values from the entire survey of the area are used in these computations.

APPENDICES

I PRODUCTION SUMMARY

II TAPE FORMAT STATEMENTS

III COMPUTER LISTINGS

IV LINE PRINTER CONTOURS

AI.A PRODUCTION SUMMARY - SURVEY TIME PERIOD

<u>ML/TL</u>	<u>DATE FLOWN</u>	<u>SURVEY LINE MILES</u>	<u>AVERAGE SPEED/DAY</u>	<u>AVERAGE ALTITUDE/DAY</u>
ML20,40,60	Feb. 22, 1980	363	139	391
ML80,100, 120,140,160 180	Feb. 23, 1980	726	140	419
ML200,220, 240,260,280 300	Feb. 24, 1980	726	140	475
ML320,340, 360,380,400 420	Feb. 25, 1980	726	139	426
ML440,460 TL5020,5040 5060,5080, 5100,5120, 5140,5160, 5180,5200	Feb. 26, 1980	932	140	433

AI-1

AI.B TEST LINE RESULTS

UNIT	1980				
	2/22	2/23	**2/24	2/25	2/26
PRE COS	33.68	32.32	33.01	32.18	30.85
POS COS	33.69	31.43	33.66	31.65	*
Tl	45.08	45.69	40.91	40.25	43.11
Tl	45.09	45.39	41.21	39.82	-
Bi	24.86	25.72	21.53	22.86	21.17
Bi	24.65	24.50	16.03	18.41	-
K	74.45	73.29	47.54	47.46	72.29
K	70.41	74.17	51.39	47.97	-
GC	1454.88	1460.35	1209.46	1202.69	1344.58
GC	1459.97	1452.78	1138.33	1191.52	-
BiAir	16.46	9.47	11.16	9.38	7.20
BiAir	9.35	15.01	31.44	14.89	-
ALT	391.69	385.05	404.93	424.16	430.34
ALT	399.93	399.50	415.62	383.74	-

* not flown because low on fuel

** changed test line location

AI-2

AI.C DIURNAL CORRECTIONS TO LINE DATA					
LINE	DIURNAL CORRECTIONS IN GAMMAS	LINE	DIURNAL CORRECTIONS IN GAMMAS	LINE	DIURNAL CORRECTIONS IN GAMMAS
ML 20	9	ML 180	0	ML 340	3
ML 40	-1	ML 200	-16	ML 360	15
ML 60	-19	ML 220	2	ML 380	6
ML 80	13	ML 240	11	ML 400	1
ML 100	11	ML 260	9	ML 420	0
ML 120	-1	ML 280	3	ML 440	-2
ML 140	-6	ML 300	-1	ML 460	-2
ML 160	2	ML 320	-10		
TL 5020	-22	TL 5100	2	TL 5160	0
TL 5040	-17	TL 5120	12	TL 5180	-2
TL 5060	-10	TL 5140	5	TL 5200	-6
TL 5080	-3				

AI.D EXPLANATORY NOTES

The magnetic data on ML80, between records 3792 and 4339, and on ML100, between records 4340 and 4595, was unrecoverable due to an equipment problem. It was therefore straight-lined between those points. There were no other processing problems, although there was a wide range on the temperature and extremely low K (potassium).

AI.E AVERAGE SPEED AND ALTITUDE DATA SUMMARY					
LINE	AVERAGE SPEED (MPH)	AVERAGE ALTITUDE (FEET)	LINE	AVERAGE SPEED (MPH)	AVERAGE ALTITUDE (FEET)
ML 20	140	386	ML 360	143	423
ML 40	139	393	ML 380	138	433
ML 60	141	393	ML 400	142	414
ML 80	140	395	ML 420	137	422
ML 100	138	398	ML 440	145	418
ML 120	142	397	ML 460	144	439
ML 140	139	411	TL 5020	139	410
ML 160	143	428	TL 5040	140	426
ML 180	139	484	TL 5060	137	548
ML 200	137	499	TL 5080	136	430
ML 220	141	480	TL 5100	140	399
ML 240	136	512	TL 5120	135	428
ML 260	146	461	TL 5140	147	399
ML 280	138	446	TL 5160	135	435
ML 300	142	451	TL 5180	144	446
ML 320	141	434	TL 5200	137	413
ML 340	137	433

APPENDIX II
TAPE FORMAT STATEMENTS

A. DESCRIPTION OF DATA TAPES

A1. General

All data tapes are 9-track, 800 BPI (NRZI), odd parity, EBCDIC code. Each tape contains a gum label giving the survey project name, month and year of survey, tape type, subcontractor name, date tape created, tape reel count, tape recording characteristics, block size in Bytes and location of tape format information.

The general description for each of the tape types is as follows:

Block Number	Description
1	Format Description
2	Tape Identification
3	First Data Block
4	Second Data Block
.	.
.	.
.	Last Data Block
EOF	

A2. Raw Spectral Data Tapes

Block Size (Physical Record): 6600 characters
Logical Record, Data : 1100 characters

1. Format Description Block (Block 1)

The Format Description utilizes 4248 characters. The remaining 2352 characters of this block are blanks.

Line Number	Character Number
1	01 0978 (DATA TAPE TYPE AND FORMAT SPECIFICATION DATE CODES)
2	
3	RAW SPECTRAL DATA TAPE
4	
5	FORMAT FOR TAPE IDENTIFICATION BLOCK (SECOND BLOCK ON TAPE)
6	
7	ITEM FORMAT DESCRIPTION
8	1 A40 QUADRANGLE NAME AS PROJECT IDENTIFICATION
9	2 A20 NAME OF SUBCONTRACTOR
10	3 I4 APPROXIMATE DATE OF SURVEY (MONTH, YEAR)

Line Number	Character Number
11	4 I1 AERIAL SYSTEM IDENTIFICATION CODE
12	5 A20 AIRCRAFT IDENTIFICATION BY TYPE AND FAA NUMBER
13	6 I3 BFEC CALIBRATION REPORT NUMBER
14	7 F6.3 4PI SYSTEM DATA COLLECTION INTERVAL TO THREE DECIMAL PLACES IN SECONDS
15	
16	8 F6.3 2PI SYSTEM DATA COLLECTION INTERVAL TO THREE DECIMAL PLACES IN SECONDS
17	
18	9 I3 NUMBER OF CHANNELS (0-3 MEV) FOR 4PI SYSTEM
19	10 I3 NUMBER OF CHANNELS (0-3 MEV) FOR 2PI SYSTEM
20	11 I3 NUMBER OF FLIGHT LINES ON THIS TAPE
21	12 I4 FIRST FLIGHT LINE NUMBER ON THIS TAPE
22	13 I6 FIRST RECORD NUMBER OF FIRST FLIGHT LINE
23	14 I3 JULIAN DATE (DAY OF YEAR) FIRST FLIGHT LINE WAS COLLECTED
24	
25	15-17 14,I6,I3 REPEAT OF ITEMS 12-14 FOR SECOND FLIGHT LINE ON THIS TAPE
26	
27	* * *
28	* * *
29	* * *
30	306-308 I4,I6,I3 REPEAT OF ITEMS 12-14 FOR 99TH FLIGHT LINE ON THIS TAPE
31	
32	
33	FORMAT FOR RAW SPECTRAL DATA RECORD (THIRD THRU LAST BLOCK ON TAPE)
34	
35	ITEM FORMAT DESCRIPTION
36	1 I1 AERIAL SYSTEM IDENTIFICATION CODE
37	2 I4 FLIGHT LINE NUMBER
38	3 I6 RECORD IDENTIFICATION NUMBER
39	4 I6 GMT TIME OF DAY (HHMMSS)
40	5 F8.4 LATITUDE TO FOUR DECIMAL PLACES IN DEGREES
41	6 F8.4 LONGITUDE TO FOUR DECIMAL PLACES IN DEGREES
42	7 F6.1 TERRAIN CLEARANCE TO ONE DECIMAL PLACE IN METERS
43	8 F7.1 TOTAL MAGNETIC FIELD INTENSITY TO ONE DECIMAL PLACE IN GAMMAS
44	
45	9 A8 SURFACE GEOLOGIC MAP UNIT CODE
46	10 I4 QUALITY FLAG CODES
47	11 F4.1 OUTSIDE AIR TEMPERATURE TO ONE DECIMAL PLACE IN DEGREES CELSIUS
48	
49	12 F5.1 OUTSIDE AIR PRESSURE TO ONE DECIMAL PLACE IN MMHG
50	13 F5.3 LIVE TIME COUNTING PERIOD TO THREE DECIMAL PLACES IN SECONDS
51	
52	14 I4 SUMMED RAW OUTPUT FROM COSMIC CHANNELS (3-6 MEV) IN COUNTS
53	
54	15 I4 RAW OUTPUT FROM CHANNEL 1 IN COUNTS
55	16 I4 RAW OUTPUT FROM CHANNEL 2 IN COUNTS
56	* * *
57	* * *
58	* * *
59	270 I4 RAW OUTPUT FROM CHANNEL 256 IN COUNTS
-	- - 2352 BLANK CHARACTERS

2. Tape Identification Block (Block 2)

The information and format for this block are indicated in lines 8 through 30 of the Format Description Block A2.1, and 1396 characters are produced. The remaining 5204 characters in this block are blanks.

If fewer than 99 flight lines exist, the unused flight line information, 13 characters per flight line, is filled with 9's through the 99th flight line.

3. Raw Spectral Data Blocks

The information and format for the logical records in these blocks are indicated in lines 36 through 59 of the Format Description Block A2.1. One logical record contains 1100 characters. There are six such logical records per 6600 character physical record or block.

The 2 π data logical record is recorded after the corresponding 4 π data collection intervals at a frequency dependent on the 2 π system data collection interval. For example, if the 4 π data collection interval is 1 second and the 2 π data collection interval is 10 seconds, then 10 records of 4 π data are recorded followed by 1 record of the 2 π data which was collected during the preceding 10 seconds. The format for the 2 π data is identical to that of the 4 π data, except for lines 40 through 49 of the Format Description Block given above. These variables are expressed in the 2 π record as all nines in the format specified for I and F fields, and all zeros for A fields.

A3. Single Record Reduced Data Tapes

Block Size (Physical Record): 6900 characters
Logical Record, Data : 138 characters

1. Format Description Block (Block 1)

The Format Description utilizes 6768 characters. The remaining 132 characters of this block are blanks.

Line Number	Character Number
1	02 0978 (DATA TAPE TYPE AND FORMAT SPECIFICATION DATE CODES)
2	
3	SINGLE RECORD REDUCED DATA TAPE
4	
5	FORMAT FOR TAPE IDENTIFICATION BLOCK (SECOND BLOCK)
6	

A11-3

Line Number	Character Number
7	ITEM FORMAT DESCRIPTION
8	1 A40 QUADRANGLE NAME AS PROJECT IDENTIFICATION
9	2 A20 NAME OF SUBCONTRACTOR
10	3 I4 APPROXIMATE DATE OF SURVEY (MONTH, YEAR)
11	4 I1 NUMBER OF AERIAL SYSTEMS USED TO COLLECT DATA FOR THIS QUADRANGLE
12	
13	5 I1 AERIAL SYSTEM IDENTIFICATION CODE FOR FIRST SYSTEM
14	6 A20 AIRCRAFT IDENTIFICATION BY TYPE AND FAA NUMBER FOR FIRST SYSTEM
15	
16	7 F6.1 NOMINAL ALTITUDE SYSTEM SENSITIVITY RELATIVE TO TERRESTRIAL POTASSIUM (K-40) TO ONE DECIMAL PLACE IN CPS PER PERCENT K FOR FIRST SYSTEM
17	
18	8 F6.1 NOMINAL ALTITUDE SYSTEM SENSITIVITY RELATIVE TO TERRESTRIAL URANIUM (BI-214) TO ONE DECIMAL PLACE IN CPS PER PPM EQUIVALENT U
19	
20	9 F6.1 NOMINAL ALTITUDE SYSTEM SENSITIVITY RELATIVE TO TERRESTRIAL THORIUM (TL-208) TO ONE DECIMAL PLACE IN CPS PER PPM EQUIVALENT TH
21	
22	10 I6 BLANK FIELD (9999999)
23	11 F6.3 4PI-SYSTEM DATA COLLECTION INTERVAL TO THREE DECIMAL PLACES IN SECONDS FOR FIRST SYSTEM
24	
25	12 F6.3 2PI-SYSTEM DATA COLLECTION INTERVAL TO THREE DECIMAL PLACES IN SECONDS FOR FIRST SYSTEM
26	
27	13 I3 NUMBER OF CHANNELS (0-3 MEV) IN 4PI SYSTEM FOR FIRST AERIAL SYSTEM
28	
29	14 I3 NUMBER OF CHANNELS (0-3 MEV) IN 2PI SYSTEM FOR FIRST AERIAL SYSTEM
30	
31	15-24 (SAME) REPEAT OF ITEMS 5-14 FOR SECOND AERIAL SYSTEM
32	* * *
33	* * *
34	* * *
35	
36	85-94 (SAME) REPEAT OF ITEMS 5-14 FOR NINTH AERIAL SYSTEM
37	
38	95 I3 NUMBER OF FLIGHT LINES ON THIS TAPE
39	
40	96 I4 FIRST FLIGHT LINE NUMBER ON THIS TAPE
41	
42	97 I6 FIRST RECORD NUMBER OF FIRST FLIGHT LINE
43	
44	98 I3 JULIAN DATE (DAY OF YEAR) FIRST FLIGHT-LINE DATA WAS COLLECTED
45	
46	99-101 I4,I6,I3 REPEAT OF ITEMS 96-98 FOR SECOND FLIGHT LINE ON THIS TAPE
47	* * *
48	* * *
49	* * *
50	390-392 I4,I6,I3 REPEAT OF ITEMS 96-98 FOR 99TH FLIGHT LINE ON THIS TAPE
51	
52	FORMAT FOR SINGLE RECORD REDUCED DATA RECORD (THIRD THRU LAST BLOCK)
53	
54	ITEM FORMAT DESCRIPTION
55	1 I1 AERIAL SYSTEM IDENTIFICATION CODE
56	2 I4 FLIGHT LINE NUMBER
57	3 I6 RECORD IDENTIFICATION NUMBER
58	4 I6 GMT TIME OF DAY (HHMMSS)
59	5 F8.4 LATITUDE TO FOUR DECIMAL PLACES IN DEGREES

A11-4

Line Number	Character Number
60	6 F8.4 LONGITUDE TO FOUR DECIMAL PLACES IN DEGREES
61	7 F6.1 TERRAIN CLEARANCE TO ONE DECIMAL PLACE IN METERS
62	8 F7.1 RESIDUAL (IGRF REMOVED) MAGNETIC FIELD INTENSITY TO ONE DECIMAL PLACE IN GAMMAS
63	
64	9 A8 SURFACE GEOLOGIC MAP UNIT CODE
65	10 I4 QUALITY FLAG CODES
66	11 F6.1 APPARENT CONCENTRATION OF TERRESTRIAL POTASSIUM (K-40) TO ONE DECIMAL PLACE IN PERCENT K
67	
68	12 F4.1 UNCERTAINTY IN TERRESTRIAL POTASSIUM TO ONE DECIMAL PLACE IN PERCENT K
69	
70	13 F6.1 APPARENT CONCENTRATION OF TERRESTRIAL URANIUM (BI-214) TO ONE DECIMAL PLACE IN PPM EQUIVALENT U
71	
72	14 F4.1 UNCERTAINTY IN TERRESTRIAL URANIUM TO ONE DECIMAL PLACE IN PPM EQUIVALENT U
73	
74	15 F6.1 APPARENT CONCENTRATION OF TERRESTRIAL THORIUM (TL-208) TO ONE DECIMAL PLACE IN PPM EQUIVALENT TH
75	
76	16 F4.1 UNCERTAINTY IN TERRESTRIAL THORIUM TO ONE DECIMAL PLACE IN PPM EQUIVALENT TH
77	
78	17 F6.1 URANIUM-TO-THORIUM RATIO TO ONE DECIMAL PLACE IN PPM EQUIVALENT U PER PPM EQUIVALENT TH
79	
80	18 F6.1 URANIUM-TO-POTASSIUM RATIO TO ONE DECIMAL PLACE IN PPM EQUIVALENT U PER PERCENT K
81	
82	19 F6.1 THORIUM-TO-POTASSIUM RATIO TO ONE DECIMAL PLACE IN PPM EQUIVALENT TH PER PERCENT K
83	
84	20 F8.1 GROSS GAMMA (0.4-3.0 MEV) COUNT RATE TO ONE DECIMAL PLACE IN COUNTS PER SECOND
85	
86	21 F6.1 UNCERTAINTY IN GROSS GAMMA COUNT RATE TO ONE DECIMAL PLACE IN COUNTS PER SECOND
87	
88	22 F5.1 ATMOSPHERIC BI-214 4PI CORRECTION TO ONE DECIMAL PLACE IN PPM EQUIVALENT U
89	
90	23 F4.1 UNCERTAINTY IN ATMOSPHERIC BI-214 4PI CORRECTION TO ONE DECIMAL PLACE IN PPM EQUIVALENT U
91	
92	24 F4.1 OUTSIDE AIR TEMPERATURE TO ONE DECIMAL PLACE IN DEGREES CELSIUS
93	
94	25 F5.1 OUTSIDE AIR PRESSURE TO ONE DECIMAL PLACE IN MMHG

2. Tape Identification Block (Block 2)

The information and format for this block are indicated in lines 8 through 49 of the Format Description Block A3.1, and 1922 characters are produced. The remaining 4978 characters of this block are blanks.

If less than nine aerial systems are used, the space allocated for additional systems is filled with 9's in the format specified for each item using I and F fields, and with zeros for A fields.

Similarly, if fewer than 99 flight lines exist, the unused flight line information, 13 characters per flight line, is filled with 9's through the 99th flight line.

A11-5

3. Single Record Reduced Data Blocks

The information and format for the logical records in these blocks are indicated in lines 55 through 94 of the Format Description Block A3.1. One logical record contains 138 characters. There are 50 such logical records per 6900 character physical record or block.

The data appearing in locations specified by lines 68, 72, 76, 86 and 90 of the Format Description Block A3.1 are 9's in the format specified in each case.

A4. Statistical Analysis Tapes (Data and Summary)
File 1: Statistical Analysis Data

Block Size (Physical Record): 8000 characters
Logical Record, Data : 160 characters

1. Format Description Block (Block 1)

The Format Description utilizes 7560 characters. The remaining 440 characters are blanks.

Line Number	Character Number	1234567890123456789012345678901234567890123456789012
1	03 0978	(DATA TAPE TYPE AND FORMAT SPECIFICATION DATE CODES)
2		
3		STATISTICAL ANALYSIS DATA TAPE
4		
5		FORMAT FOR TAPE IDENTIFICATION BLOCK (SECOND BLOCK)
6		
7	ITEM	FORMAT DESCRIPTION
8	1	A40 QUADRANGLE NAME AS PROJECT IDENTIFICATION
9	2	A20 NAME OF SUBCONTRACTOR
10	3	I4 APPROXIMATE DATE OF SURVEY (MONTH, YEAR)
11	4	I1 NUMBER OF AERIAL SYSTEMS USED TO COLLECT DATA FOR THIS QUADRANGLE
12		
13	5	I1 AERIAL SYSTEM IDENTIFICATION CODE FOR FIRST SYSTEM
14	6	A20 AIRCRAFT IDENTIFICATION BY TYPE AND FAA NUMBER FOR FIRST SYSTEM
15		
16	7	F6.1 NOMINAL ALTITUDE SYSTEM SENSITIVITY RELATIVE TO TERRESTRIAL POTASSIUM (K-40) TO ONE DECIMAL PLACE IN CPS PER PERCENT K
17		
18		
19	8	F6.1 NOMINAL ALTITUDE SYSTEM SENSITIVITY RELATIVE TO TERRESTRIAL URANIUM (BI-214) TO ONE DECIMAL PLACE IN CPS PER PPM EQUIVALENT U
20		
21		
22	9	F6.1 NOMINAL ALTITUDE SYSTEM SENSITIVITY RELATIVE TO TERRESTRIAL THORIUM (TL-208) TO ONE DECIMAL PLACE IN CPS PER PPM EQUIVALENT TH
23		
24		
25	10	I6 BLANK FIELD (999999)
26	11	F6.3 4PI-SYSTEM DATA COLLECTION INTERVAL TO THREE DECIMAL PLACES IN SECONDS FOR FIRST SYSTEM
27		
28	12	F6.3 2PI-SYSTEM DATA COLLECTION INTERVAL TO THREE DECIMAL PLACES IN SECONDS FOR FIRST SYSTEM
29		

Line Number	Character Number	1234567890123456789012345678901234567890123456789012
30	13	I3 NUMBER OF CHANNELS (0-3 MEV) IN 4PI SYSTEM FOR FIRST AERIAL SYSTEM
31		
32	14	I3 NUMBER OF CHANNELS (0-3 MEV) IN 2PI SYSTEM FOR FIRST AERIAL SYSTEM
33		
34	15-24	(SAME) REPEAT OF ITEMS 5-14 FOR SECOND AERIAL SYSTEM
35	*	*
36	*	*
37	*	*
38	85-94	(SAME) REPEAT OF ITEMS 5-14 FOR NINTH AERIAL SYSTEM
39	95	I3 NUMBER OF FLIGHT LINES ON THIS TAPE
40	96	I4 FIRST FLIGHT LINE NUMBER ON THIS TAPE
41	97	I6 FIRST RECORD NUMBER OF FIRST FLIGHT LINE
42	98	I3 JULIAN DATE (DAY OF YEAR) FIRST FLIGHT LINE DATA WAS COLLECTED
43		
44	99-101	I4,I6,I3 REPEAT OF ITEMS 96-98 FOR SECOND FLIGHT LINE ON THIS TAPE
45		
46	*	*
47	*	*
48	*	*
49	390-392	I4,I6,I3 REPEAT OF ITEMS 96-98 FOR 99TH FLIGHT LINE ON THIS TAPE
50		
51		
52		FORMAT FOR STATISTICAL ANALYSIS DATA RECORD (THIRD THRU LAST BLOCK)
53		
54	ITEM	FORMAT DESCRIPTION
55	1	I1 AERIAL SYSTEM IDENTIFICATION CODE
56	2	I4 FLIGHT LINE NUMBER
57	3	I6 RECORD IDENTIFICATION NUMBER
58	4	I6 GMT TIME OF DAY (HHMMSS)
59	5	F8.4 LATITUDE TO FOUR DECIMAL PLACES IN DEGREES
60	6	F8.4 LONGITUDE TO FOUR DECIMAL PLACES IN DEGREES
61	7	F6.1 TERRAIN CLEARANCE TO ONE DECIMAL PLACE IN METERS
62	8	F7.1 RESIDUAL (IGRF REMOVED) MAGNETIC FIELD INTENSITY TO ONE DECIMAL PLACE IN GAMMAS
63		
64	9	A8 SURFACE GEOLOGIC MAP UNIT CODE
65	10	I5 QUALITY FLAG CODES
66	11	F6.1 AVERAGED CONCENTRATION OF TERRESTRIAL POTASSIUM (K-40) TO ONE DECIMAL PLACE IN PERCENT K
67		
68	12	F4.1 UNCERTAINTY IN TERRESTRIAL POTASSIUM TO ONE DECIMAL PLACE IN PERCENT K
69		
70	13	F5.1 POTASSIUM STANDARD DEVIATION FROM THE MEAN TO ONE DECIMAL PLACE AND ALGEBRAICALLY SIGNED
71		
72	14	F6.1 AVERAGED CONCENTRATION OF TERRESTRIAL URANIUM (BI-214) TO ONE DECIMAL PLACE IN PPM EQUIVALENT U
73		
74	15	F4.1 UNCERTAINTY IN TERRESTRIAL URANIUM TO ONE DECIMAL PLACE IN PPM EQUIVALENT U
75		
76	16	F5.1 URANIUM STANDARD DEVIATION FROM THE MEAN TO ONE DECIMAL PLACE AND ALGEBRAICALLY SIGNED
77		
78	17	F6.1 AVERAGED CONCENTRATION OF TERRESTRIAL THORIUM (TL-208) TO ONE DECIMAL PLACE IN PPM EQUIVALENT TH
79		
80	18	F4.1 UNCERTAINTY IN TERRESTRIAL THORIUM TO ONE DECIMAL PLACE IN PPM EQUIVALENT TH
81		

Line Number	Character Number	1234567890123456789012345678901234567890123456789012
82	19	F5.1 THORIUM STANDARD DEVIATION FROM THE MEAN TO ONE DECIMAL PLACE AND ALGEBRAICALLY SIGNED
83		
84	20	F8.1 GROSS GAMMA (0.4-3.0 MEV) COUNT RATE TO ONE DECIMAL PLACE IN COUNTS PER SECOND
85		
86	21	F6.1 UNCERTAINTY IN GROSS GAMMA COUNT RATE TO ONE DECIMAL PLACE IN COUNTS PER SECOND
87		
88	22	F5.1 ATMOSPHERIC BI-214 4PI CORRECTION TO ONE DECIMAL PLACE IN PPM EQUIVALENT U
89		
90	23	F4.1 UNCERTAINTY IN ATMOSPHERIC BI-214 4PI CORRECTION TO ONE DECIMAL PLACE IN PPM EQUIVALENT U
91		
92	24	F6.1 AVERAGED URANIUM-TO-THORIUM RATIO TO ONE DECIMAL PLACE IN PPM EQUIVALENT U PER PPM EQUIVALENT TH
93		
94	25	F5.1 URANIUM-TO-THORIUM RATIO STANDARD DEVIATION FROM THE MEAN TO ONE DECIMAL PLACE AND ALGEBRAICALLY SIGNED
95		
96	26	F6.1 AVERAGED URANIUM-TO-POTASSIUM RATIO TO ONE DECIMAL PLACE IN PPM EQUIVALENT U PER PERCENT K
97		
98	27	F5.1 URANIUM-TO-POTASSIUM RATIO STANDARD DEVIATION FROM THE MEAN TO ONE DECIMAL PLACE AND ALGEBRAICALLY SIGNED
99		
100		
101	28	F6.1 AVERAGED THORIUM-TO-POTASSIUM RATIO TO ONE DECIMAL PLACE IN PPM EQUIVALENT TH PER PERCENT K
102		
103	29	F5.1 THORIUM-TO-POTASSIUM RATIO STANDARD DEVIATION FROM THE MEAN TO ONE DECIMAL PLACE AND ALGEBRAICALLY SIGNED
104		
105		

2. Tape Identification Block (Block 2)

The information and format for this block are indicated in lines 8 through 49 of the Format Description Block A4.1, and 1922 characters are produced. The remaining 6078 characters of this block are blanks.

If less than nine aerial systems are used, the space allocated for additional systems is filled with 9's in the format specified for each item using I and F fields, and with zeros for A fields.

Similarly, if fewer than 99 flight lines exist, the unused flight line information, 13 characters per flight line, is filled with 9's through the 99th flight line.

3. Statistical Analysis Data Blocks

The information and format for the logical records in these blocks are indicated in lines 55 through 103 of the Format Description Block A4.1. One logical record contains 160 characters. There are 50 such logical records per 8000 character physical record or block.

The data appearing in locations specified by lines 68, 74, 80, 86 and 90 of the Format Description Block A4.1 are 9's in the format specified in each case.

File 2: Statistical Analysis Summary

Block Size (Physical Record): 7000 characters
Logical Record (Data) : 140 characters

1. Format Description Block (Block 1)

The Format Description utilizes 4320 characters. The remaining 2680 characters are blanks.

Line Number	Character Number	1234567890123456789012345678901234567890123456789012
1	05	0978 (DATA TAPE TYPE AND FORMAT SPECIFICATION DATE CODE)
2		
3		STATISTICAL ANALYSIS SUMMARY TAPE (OR FILE)
4		
5		FORMAT FOR TAPE IDENTIFICATION BLOCK (SECOND BLOCK)
6		
7	ITEM	FORMAT DESCRIPTION
8	1	A40 QUADRANGLE NAME AS PROJECT IDENTIFICATION
9	2	A20 NAME OF SUBCONTRACTOR
10	3	I4 APPROXIMATE DATE OF SURVEY (MONTH, YEAR)
11	4	I6 NUMBER OF GEOLOGIC MAP UNITS USED FOR THIS QUADRANGLE
12		
13		
14		FORMAT FOR STATISTICAL ANALYSIS SUMMARY DATA RECORD (THIRD THRU LAST BLOCK)
15		
16		
17	ITEM	FORMAT DESCRIPTION
18	1	A8 SURFACE GEOLOGIC MAP UNIT IDENTIFYING CODE
19	2	I6 TOTAL RECORDS FOR GEOLOGIC MAP UNIT
20	3	I6 NUMBER OF POTASSIUM RECORDS COMPUTED FOR GEOLOGIC UNIT
21		
22	4	F6.1 POTASSIUM CONCENTRATION MEAN TO ONE DECIMAL PLACE IN PERCENT K
23		
24	5	F6.1 POTASSIUM CONCENTRATION STANDARD DEVIATION TO ONE DECIMAL PLACE IN PERCENT K
25		
26	6	A3 POTASSIUM CONCENTRATION DISTRIBUTION CODE
27	7	I6 NUMBER OF URANIUM RECORDS COMPUTED FOR GEOLOGIC UNIT
28	8	F6.1 URANIUM CONCENTRATION MEAN TO ONE DECIMAL PLACE IN PPM EQUIVALENT U
29		
30	9	F6.1 URANIUM CONCENTRATION STANDARD DEVIATION TO ONE DECIMAL PLACE IN PPM EQUIVALENT U
31		
32	10	A3 URANIUM CONCENTRATION DISTRIBUTION CODE
33	11	I6 NUMBER OF THORIUM RECORDS COMPUTED FOR GEOLOGIC UNIT
34	12	F6.1 THORIUM CONCENTRATION MEAN TO ONE DECIMAL PLACE IN PPM EQUIVALENT TH
35		
36	13	F6.1 THORIUM CONCENTRATION STANDARD DEVIATION TO ONE DECIMAL PLACE IN PPM EQUIVALENT TH
37		

Line Number	Character Number	1234567890123456789012345678901234567890123456789012
38	14	A3 THORIUM CONCENTRATION DISTRIBUTION CODE
39	15	I6 NUMBER OF URANIUM-TO-THORIUM RATIO RECORDS COMPUTED FOR GEOLOGIC UNIT
40		
41	16	F6.1 URANIUM-TO-THORIUM RATIO MEAN TO ONE DECIMAL PLACE IN PPM EQUIVALENT U PER PPM EQUIVALENT TH
42		
43	17	F6.1 URANIUM-TO-THORIUM RATIO STANDARD DEVIATION TO ONE DECIMAL PLACE IN PPM EQUIVALENT U PER PPM EQUIVALENT TH
44		
45		
46	18	A3 URANIUM-TO-THORIUM RATIO DISTRIBUTION CODE
47	19	I6 NUMBER OF URANIUM-TO-POTASSIUM RATIO RECORDS COMPUTED FOR GEOLOGIC UNIT
48		
49	20	F6.1 URANIUM-TO-POTASSIUM RATIO MEAN TO ONE DECIMAL PLACE IN PPM EQUIVALENT U PER PERCENT K
50		
51	21	F6.1 URANIUM-TO-POTASSIUM RATIO STANDARD DEVIATION TO ONE DECIMAL PLACE IN PPM EQUIVALENT U PER PERCENT K
52		
53	22	A3 URANIUM-TO-POTASSIUM RATIO DISTRIBUTION CODE
54	23	I6 NUMBER OF THORIUM-TO-POTASSIUM RATIO RECORDS COMPUTED FOR GEOLOGIC UNIT
55		
56	24	F6.1 THORIUM-TO-POTASSIUM RATIO MEAN TO ONE DECIMAL PLACE IN PPM EQUIVALENT TH PER PERCENT K
57		
58	25	F6.1 THORIUM-TO-POTASSIUM RATIO STANDARD DEVIATION TO ONE DECIMAL PLACE IN PPM EQUIVALENT TH PER PERCENT K
59		
60	26	A3 THORIUM-TO-POTASSIUM RATIO DISTRIBUTION CODE
	2.	Tape Identification Block (Block 2)
		The information and format for this block are indicated in lines 8 through 11 of the Format Description Block A6.1, and 70 characters are produced. The remaining 6930 characters of this block are blanks.
	3.	Statistical Analysis Summary Data Blocks
		The information and format for the logical records in these blocks are indicated in lines 18 through 60 of the Format Description Block A6.1. One logical record contains 140 characters. There are 50 such logical records per 7000 character physical record or block.
	A5.	Magnetic Data Tapes
		Block Size (Physical Record): 8000 characters Logical Record (Data) : 80 characters
	1.	Format Description Block (Block 1)
		The Format Description utilizes 3384 characters. The remaining 4616 characters are blanks.

Line Number	Character Number	1234567890123456789012345678901234567890123456789012
1	04	0978 (DATA TAPE TYPE AND FORMAT SPECIFICATION DATE CODES)
2		
3		MAGNETIC DATA TAPE
4		
5		FORMAT FOR TAPE IDENTIFICATION BLOCK (SECOND BLOCK)
6		
7	ITEM	FORMAT DESCRIPTION
8	1	A40 QUADRANGLE NAME AS PROJECT IDENTIFICATION
9	2	A20 NAME OF SUBCONTRACTOR
10	3	I4 APPROXIMATE DATE OF SURVEY (MONTH, YEAR)
11	4	I3 NUMBER OF FLIGHT LINES ON THIS TAPE
12	5	I4 FIRST FLIGHT LINE ON THIS TAPE
13	6	I6 FIRST RECORD NUMBER OF FIRST FLIGHT LINE
14	7	I3 JULIAN DATE (DAY OF YEAR) FIRST FLIGHT LINE DATA WAS COLLECTED
15		
16	8	F8.4 LATITUDE OF GROUND BASE STATION TO FOUR DECIMAL PLACES IN DEGREES FOR FIRST FLIGHT LINE
17		
18	9	F8.4 LONGITUDE OF GROUND BASE STATION TO FOUR DECIMAL PLACES IN DEGREES FOR FIRST FLIGHT LINE
19		
20	10-14	(SAME) REPEAT OF ITEMS 5-9 FOR SECOND FLIGHT LINE ON THIS TAPE
21		
22	*	*
23	*	*
24	*	*
25	495-499	(SAME) REPEAT OF ITEMS 5-9 FOR 99TH FLIGHT LINE ON THIS TAPE
26		
27		
28		FORMAT FOR MAGNETIC DATA RECORD (THIRD THRU LAST BLOCK)
29		
30	ITEM	FORMAT DESCRIPTION
31	1	I1 AERIAL SYSTEM IDENTIFICATION CODE
32	2	I4 FLIGHT LINE NUMBER
33	3	I6 RECORD IDENTIFICATION NUMBER
34	4	I6 GMT TIME OF DAY (HHMMSS)
35	5	F8.4 LATITUDE TO FOUR DECIMAL PLACES IN DEGREES
36	6	F8.4 LONGITUDE TO FOUR DECIMAL PLACES IN DEGREES
37	7	F6.1 TERRAIN CLEARANCE TO ONE DECIMAL PLACE IN METERS
38	8	F5.1 OUTSIDE AIR PRESSURE TO ONE DECIMAL PLACE IN MMHG
39	9	A8 SURFACE GEOLOGIC MAP UNIT CODE
40	10	F7.1 TOTAL MAGNETIC FIELD INTENSITY TO ONE DECIMAL PLACE IN GAMMAS
41		
42	11	F7.1 RESIDUAL (IGRF REMOVED) MAGNETIC FIELD INTENSITY TO ONE DECIMAL PLACE IN GAMMAS
43		
44	12	F7.1 DIURNAL MAGNETIC INTENSITY VARIATION TO ONE DECIMAL PLACE IN GAMMAS
45		
46	13	F7.1 MAGNETIC DEPTH-TO-BASEMENT TO ONE DECIMAL PLACE IN METERS (IF REQUIRED)
47		

2. Tape Identification Block (Block 2)

The information and format for this block are indicated in lines 8 through 25 of the Format Description Block A5.1, and 2938 characters are produced. The remaining 5062 characters of this block are blanks.

If fewer than 99 flight lines exist, the unused flight line information, 29 characters per flight line, is filled with 9's through the 99th flight line in the format indicated.

3. Magnetic Data Blocks

The information and format for the logical records in these blocks are indicated in lines 31 through 46 of the Format Description Block A5.1. One logical record contains 80 characters. There are 100 such logical records per 8000 character physical record or block.

If the magnetic depth-to-basement is not required, this item is expressed as 99999.9.

B. DESCRIPTION OF LISTINGS

B1. Single record reduced data listings: include the following information on Microfiche:

ITEM	DESCRIPTION
REC	Sequential record number
Lat	Location Y in latitude
Long	Location X in longitude
RMag	Residual magnetic field, gammas
Alt	Surface altitude
GEO UNIT	Geologic Type
AKUT	A=Altitude; K=Potassium; U=Uranium T=Thorium - Results of statistical adequacy test
COS	Cosmic c/s
BiAir	Airborne ²¹⁴ Bi, 4π data
GC	Gross count, .4 MeV - 2.8 MeV
T ₂	²⁰⁸ Tl c/s
Bi	²¹⁴ Bi c/s
K	⁴⁰ K c/s
BI:T ₂	Ratio
BI:k	Ratio
T ₂ :K	Ratio
TEMP	Outside Air Temperature (°C)
BP	Atmospheric Pressure (In. Hg)

B2. Averaged record data listings: include the following information on Microfiche:

ITEM	DESCRIPTION
REC	Sequential Record number
GEO UNIT	Geologic type
AKUT	A=Altitude; K=Potassium; U=Uranium; T=Thorium - Results of statistical adequacy test
Long	Longitude of X location of geologic type
Lat	Latitude of Y location of geologic type
RMag	Residual magnetic field, gammas
COS	Cosmic, 4π
BiAir	Atmospheric Bi, 4π
GC	Gross count, c/s

ITEM

DESCRIPTION

T ₂	T ₂ value, c/s
Rank	T ₂ standard deviation rank
Bi	Bi value, c/s
Rank	Bi standard deviation rank
K	K value, c/s
Rank	K standard deviation rank
Bi/T ₂	Ratio value
Rank	Bi/T ₂ standard deviation rank
Bi/K	Ratio value
Rank	Bi/K standard deviation rank
T ₂ /K	Ratio value
Rank	T ₂ /K standard deviation rank

THE UNIVERSITY OF CHICAGO

ATV-2 Line Printer Contour

GEODATA INTERNATIONAL, INC.
DALLAS, TEXAS

AC 0.30

0.45<K< 0.60

0.75<K< 0.90

1.05<K< 1.20

1.35<K< 1.50

1.65<K< 1.80

1.95<K< 2.10

2.25<K< 2.40

GEODATA INTERNATIONAL, INC.
DALLAS, TEXAS

A 0.140

0.210< 0.280

0.350< 0.420

0.440< 0.560

0.630< 0.700

0.770< 0.840

0.910< 0.980

1.050< 1.120

1.190< 1.260

1.330< 1.400

AIV-4 Line Printer Contour

GEODATA INTERNATIONAL, INC.
DALLAS, TEXAS

A < 200

.240<< .260

.320<< .360

.400<< .440

.480<< .520

.560<< .600

.640<< .680

.720<< .760

Line Printer Contour

GEODATA INTERNATIONAL, INC.
DALLAS, TEXAS

1.40<C< 2.70	3.40<C< 4.50	5.40<C< 6.30	7.20<C< 8.10	9.00<C< 9.90
10.40<C< 11.70	12.40<C< 13.50	14.40<C< 15.30	16.20<C< 17.10	18.00<C< 18.90
19.40<C< 20.70

SEA DATA INTERNATIONAL, INC.
DALLAS, TEXAS

400.0<K -350.	300.0<K -250.	200.0<K -150.
400.0<K -350.	300.0<K -250.	200.0<K -150.
400.0<K -350.	300.0<K -250.	200.0<K -150.
400.0<K -350.	300.0<K -250.	200.0<K -150.

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