BRAZIL AIRBORNE RADIOMETRIC MAPPING PROJECT (BARMP)

Technical Report and Survey Atlas

April 1997

A Collaboration between

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SALES OF FINAL PRODUCTS

The sales of all Final Products of the Brazil Airborne Radiometric Mapping Project (BARMP) by CPRM and PGW are governed by Addendum No. 1 to the Project Document: Application of Compilation, Processing and Back-Calibration Techniques to the Production of Airborne Radiometric Maps of Brazil, Canada-Brazil Co-operation Project for Sustainable Resources in the Minerals Sector signed on February 13, 1998. Prior to this date all materials pertaining to the BARMP including digital data, maps and the Technical Report and Survey Atlas were confidential to the BARMP sponsors.

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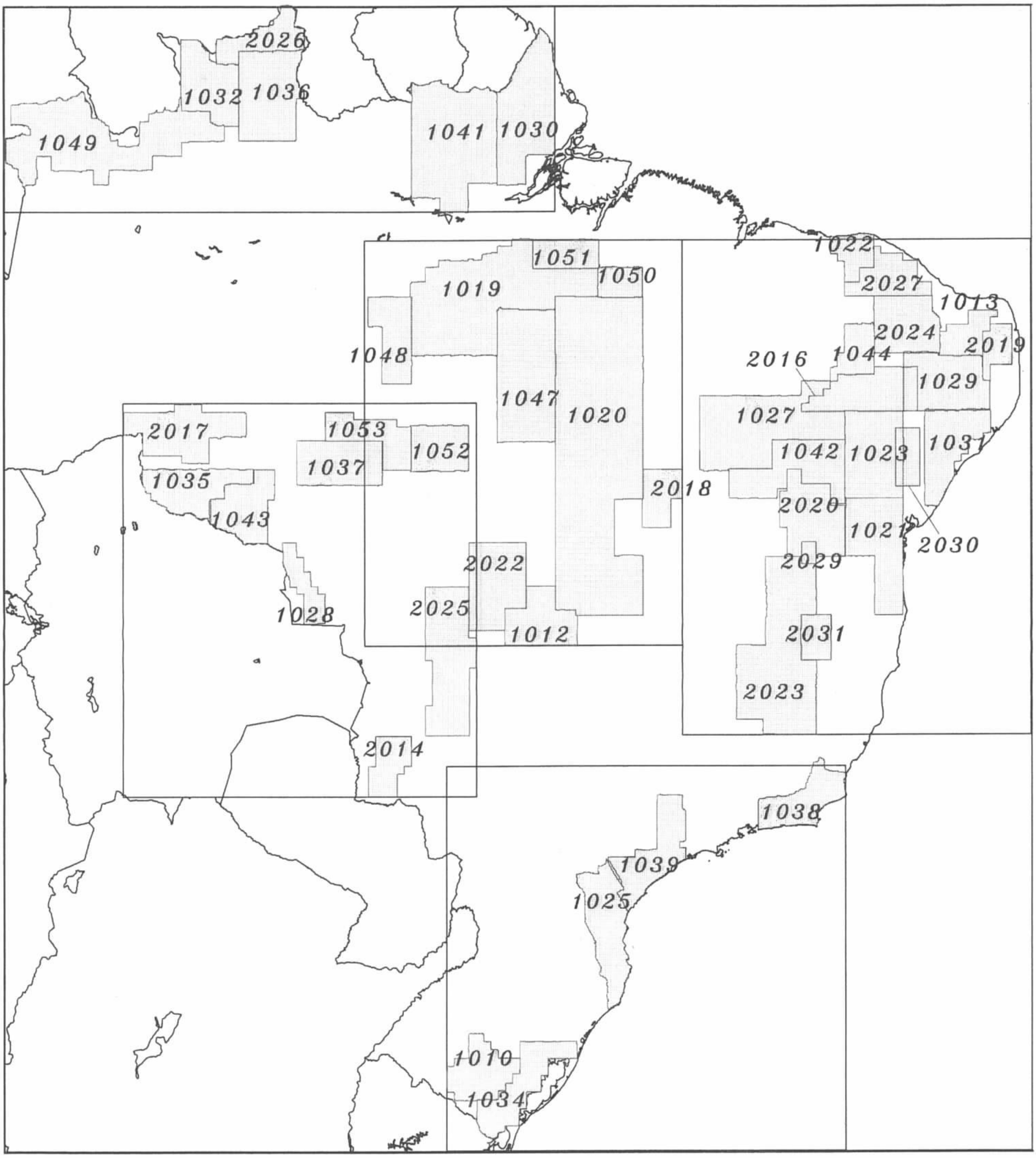
1. AIM AND SCOPE OF PROJECT

Airborne radiometric surveys have been carried out widely over Brazil in the last thirty years. The Sketch Map shown in Map1 illustrates the extent of coverage in Brazil and all of these surveys were included in BARMP. The total survey coverage exceeded 2.2 million line kms for Total Count and the three Radioelements (K, U, Th).

The primary aim of the project has been to produce a comprehensive, unified database of available digital radiometric data for Brazil. The success of the project has required the solution of a number of technical and scientific problems. These included editing of large volumes of radiometric survey data, levelling and integrating the various radioelement datasets and back-calibration of six various airborne systems that were employed to fly the forty-two separate surveys.

In addition, the success of BARMP has been due, in large part, to the co-operation between PGW and Companhia de Pesquisa de Recursos Minerais (CPRM). In particular, CPRM has been extremely helpful in the process of retrieving data from the official archives, verifying the survey and system specifications for each of the forty-two airborne surveys and in supplying all necessary materials and support personnel in order to carry out the field operations associated with the back-calibrations.



Map 1

Brazil Airborne Radiometric Mapping Project (BARMP)
Survey Coverage and Map Sheet Layout

2. DATA PROCESSING:

To facilitate the data processing, the CPRM digital data files were reformatted so that each file contained only one radioelement channel. The profile data were reprojected into the Equatorial Mercator projection (the same projection as SAMMP). This uses a reference sphere whose radius is the equatorial radius of the Clarke 1880 spheroid.

2.i) SPIKE REMOVAL

From inspection of the profiles, it was obvious that erroneous data had been previously assigned a value of zero. This was corrected by assigning the dummy value to all zero valued points.

A spike removal filter was applied to eliminate any noise spikes of one or two points. The profile data were filtered with a low-pass-non-linear Naudy filter with a ½ wavelength of twice the sample distance. Following the removal of noise spikes, the data were filtered using a 5 point smoothing filter with the following coefficients: 0.1107, 0.2215, 0.3356, 0.2215, 0.1107.

2.ii) MICROLEVELLING

The smoothed data were gridded using a minimum curvature surface fitting algorithm (GIPSI Rangrid, PGW software package) with a cell equal to 1/4 of the line separation. Then the data was filtered to remove flight-line noise, i.e. time-dependent variations in measurement sensitivity and back ground noise level which show up in the gridded data as stripes in the flight line direction. A "stripe" means a feature with a large length-to-width aspect ratio, or in other words a long wavelength in one direction (i.e. along the flight lines) and a considerably shorter wavelength in the perpendicular direction. Flight line noise was removed by a filtering process known as micro-levelling, which analyses the data on the basis of frequency content in different directions.

The first step in micro-levelling is to apply two Fourier-domain filters to the grid: a directional cosine-squared filter and a Butterworth high-pass filter. The effect of these filters is to pass only those features which are narrow (short wavelength) in the direction perpendicular to the flight lines. Values from this filtered grid (called the "decorrugation noise grid") are extracted to make a new channel in the profile database which contains the flightline noise plus some geologic signal. The "noise" channel is then filtered with a long wavelength Naudy lowpass filter to separate flight line noise from shorter wavelength geological features. The cutoff wavelength of the low-pass profile filter is set to be several times larger than the cutoff wavelength of the high-pass grid filter which was previously applied, so that the final filtered noise channel contains only "stripe" features which are considerably longer in the flight line direction than in the perpendicular direction. Subtracting this filtered noise channel from the original data removes flight line noise.

In certain instances, geologic signal can be distinguished from the noise by its greater amplitude. For these instances, an amplitude limiting filter can be applied to remove the high amplitude geologic signal from the noise channel before the Naudy low-pass filter is applied. This allows geological signal to be preserved, even for features which happen to lie parallel to the flight line direction, as long as their amplitude is greater than that of the noise.

Flight line noise stripes may be long and wide (10 km x 100km) or short and narrow (1km x 10km), so it is sometimes necessary to apply micro-levelling twice, once with short filter settings to remove small-scale noise, and once again with long filter settings to remove the larger noise features.

2.iii) APPLICATION OF BACK-CALIBRATED SENSITIVITIES AND SURVEY LINKING

Following microlevelling, the back-calibration sensitivities were applied to convert the radio-element count data to radio-element concentration. At the same time, adjacent surveys were

linked together to form a contiguous grid. Not every survey was individually back-calibrated. Often the same airborne system was used in several surveys, so in these cases one representative survey was chosen for back-calibration, and then the same set of back calibrated sensitivities were applied to all the surveys flown with the same system. Historically in Brazil six different airborne systems have been used, so six surveys (1010, 1020, 1022, 1038, 1044, and 2027) were back-calibrated - one for each system. This provided a good approximation of the sensitivities for all the surveys. However, even though the same system was used for two surveys the sensitivities may be slightly different because of differences in the calibration of the instrument, element window sizes, stripping procedure or processing of the data. To make the appropriate adjustment to the sensitivities for each survey, first the appropriate back-calibrated sensitivities (based on the six back-calibrations) were applied. The concentration grids for all the surveys were linked together then adjustments were made to the sensitivities so that the concentrations of all the surveys matched the concentration levels of the back-calibrated surveys. These adjusted sensitivity values were then applied to the profile data and have been recorded in the Survey Atlas.

An additional complication in linking surveys was that some had a higher background noise level than others. The grids of noisy surveys had a noticeable positive base level shift with respect to other (quieter) surveys. In order to obtain a good fit between adjoining surveys it was sometimes necessary to subtract off this base level of noise. In such cases the same base level shift was applied to the profile data. The base level removed from each radioelement channel was recorded in the atlas.

An example of the data processing is given for the Thorium channel of surveys 1032 and 1036 (Figure 1). Figure 1a shows a grid of the stripped count rate data recovered from the CPRM archives, and Figure 1b shows the final reprocessed concentration values. Flight line noise has been removed, resulting in a much clearer image of the geology. Back-calibration has brought the two surveys to a common level. The reprocessed grids link smoothly, with good continuity of geological features across the survey boundary.

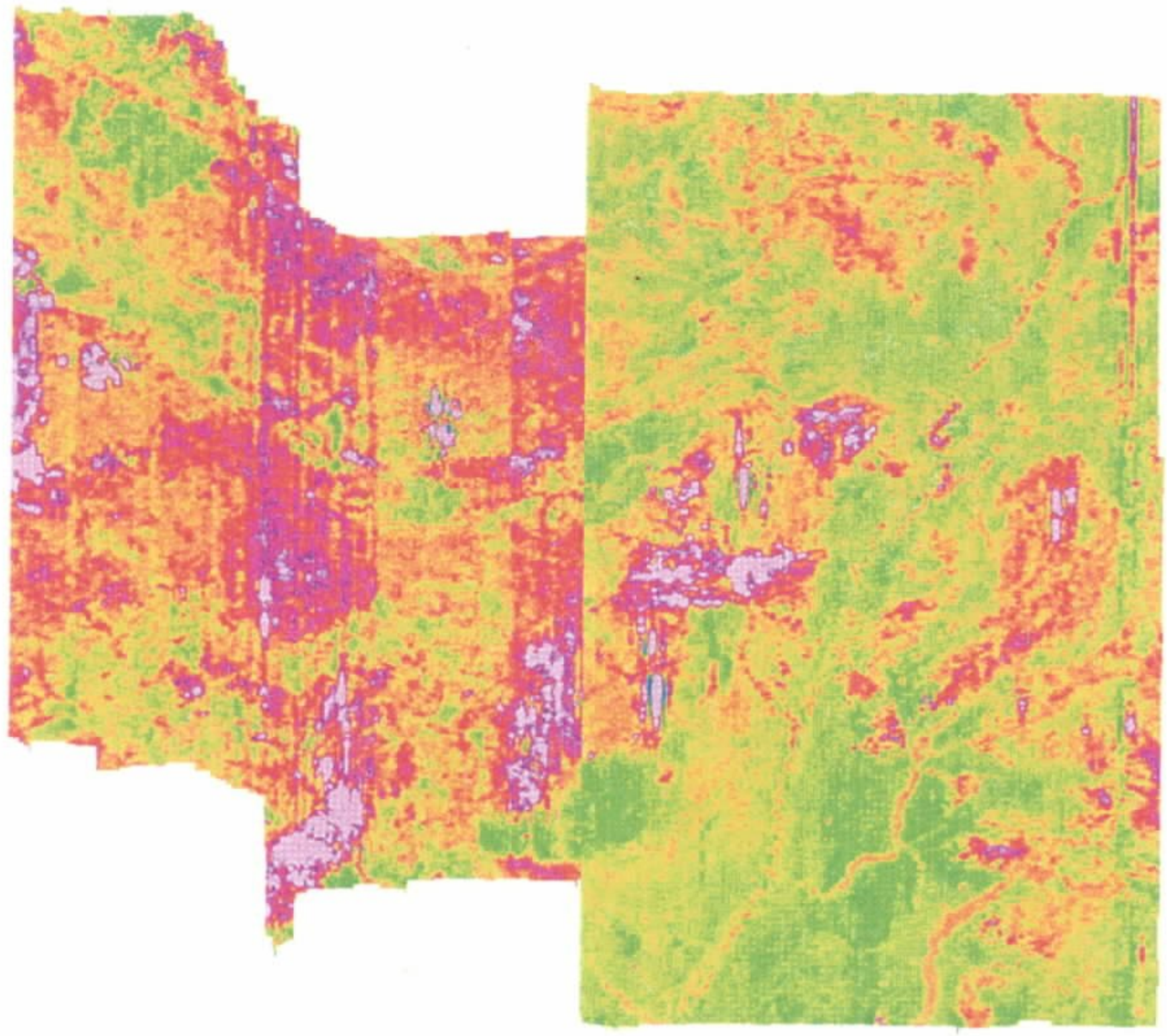


Figure 1a: Grid of stripped Thorium count rate data for surveys 1032 and 1036 as recovered from CPRM archives.

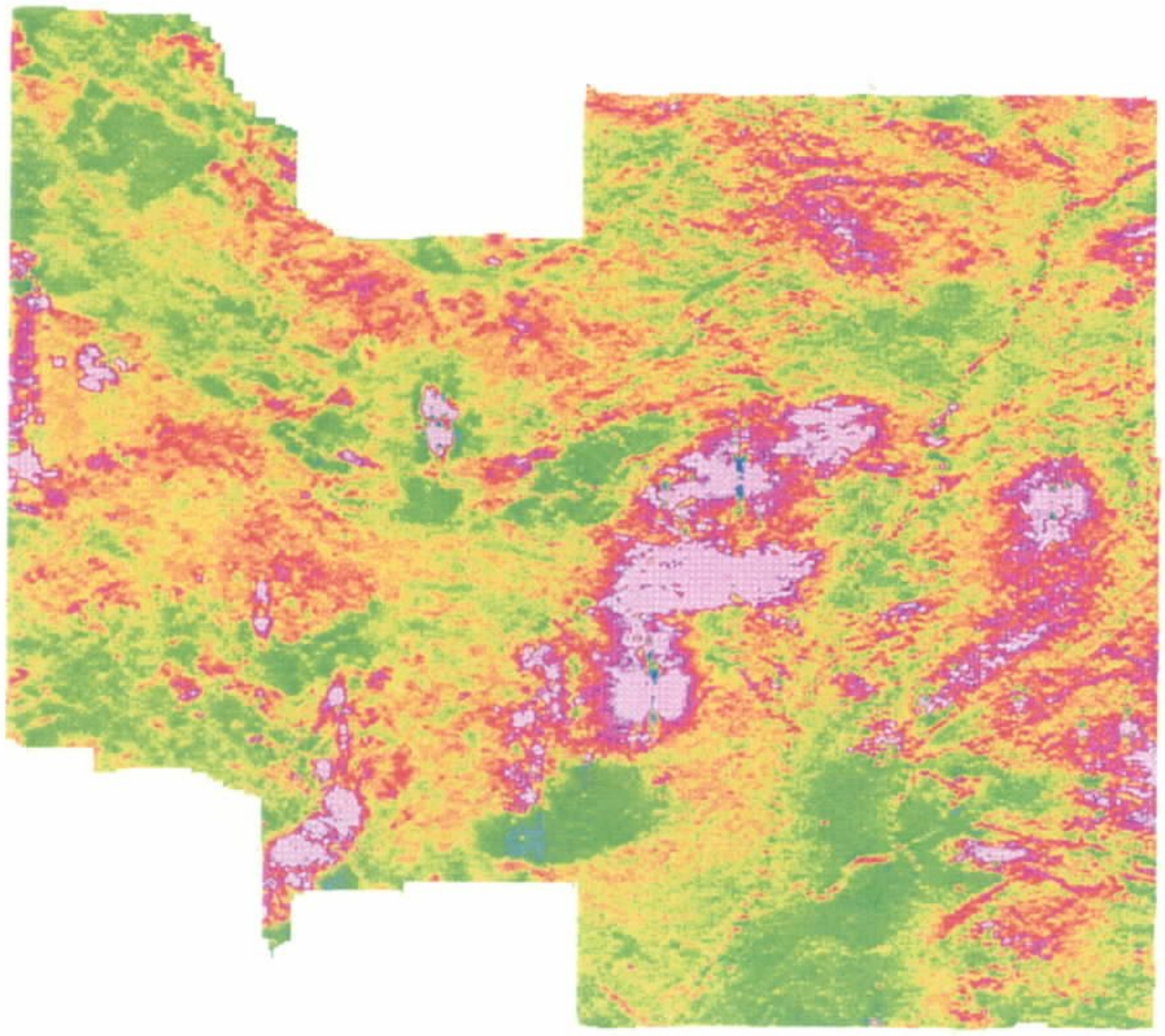


Figure 1b: Grid of reprocessed equivalent Thorium concentration for surveys 1032 and 1036.

3) BACK-CALIBRATION

3.i) Introduction

Back-calibration is a method used to convert airborne radiometric data from counts per second (cps) to ground concentrations. This method is used for surveys that were not converted to ground concentrations at the time the survey was flown. In Brazil, all the surveys currently at CPRM required back-calibration (CPRM will have all future surveys in Brazil converted to ground concentrations). It is preferable to have airborne radiometric data in ground concentration to be able to compare directly the radiometric character of the geology for different surveys (cps values are dependent on the survey specifications). In order to link surveys together into a crafted data set it is essential to have all the data in ground concentrations.

The sensitivities calculated from the back-calibration method are the values used to convert from airborne data in cps to ground concentration. A sensitivity must be calculated for each of potassium, uranium, thorium and total count for every unique survey configuration. The back-calibration method calculates the sensitivities of an airborne radiometric survey by taking ground concentration readings at various sites within a survey area using a portable gamma-ray spectrometer. These ground concentrations are then compared to the airborne data directly above the ground station to determine the correct sensitivities. The calculated sensitivities for each of the three radio-elements and total count can then be applied to the data collected in cps to compute the ground concentrations.

3.ii) Selecting Surveys for the Back-Calibration Method

Forty-two digital airborne radiometric surveys were included in the BARMP project. The sensitivities for all these surveys had to be calculated using the back-calibration method. It was not necessary to back-calibration every survey. The surveys were grouped according to survey specifications. Surveys with the same crystal volume and survey altitude were grouped together

and one back-calibration was used to calculate the sensitivities for the entire group (See Annex A: Airborne Radiometric Survey Groups). The sensitivities for surveys within the group with different survey specifications such as the spectral energy windows were adjusted after the back-calibration.

Once the surveys were grouped, one survey for each group was selected to be back-calibrated . All the surveys in a group were assessed to determine the best survey to be back-calibrated. Several criteria were used to select the best surveys for back-calibration. The survey had to have areas of low topographic relief that corresponded with areas of relatively high radioactivity. It was also important that the selected survey area possessed good access, was relatively dry and was not heavily forested. The forty-two BARMP surveys were divided into six group and the following six standard surveys were selected to be back-calibrated.

1) 1044 Borda Leste da Bacia do Maranhao, crystal size group 1024 cubic inches
2) 2027 Itatira, crystal size group 1017.87 cubic inches
3) 1022 Rio Acarau, crystal size group 830.94 cubic inches
4) 1010 Camaqua, crystal size group 2491.59 cubic inches
5) 1020 Brasil-Canada, crystal size group 1077 cubic inches
6) 1038 San Paulo-Rio de Janeiro part II, crystal size group 3072 cubic inches

These surveys were selected not only on the criteria mentioned above but also because these surveys were known to be of high quality. i.e. the data was properly collected and processed.

3.iii) Selecting Back-Calibration Sites

Once the surveys to be back-calibrated were selected then the sites where the back-calibration readings were taken had to be selected prior to going into the field. For each of the six surveys approximately forty back-calibration sites were selected. Only twenty sites were required to complete the back-calibration at each survey however many sites were eliminated during the field

work.

To select the sites, a grid was generated for each of the radioelements (potassium, uranium and thorium) and total count. These grids were then compared to topographic maps to locate areas that had both radiometric high areas that coincided with topographic flat areas. Once these areas were located a plot of the flight lines printed on transparent paper was over laid on the 1:50,000 or 1:100,000 topographic map sheets. Then potential sites were located on the topographic-flight line maps where the flight lines crossed easily recognizable locations on the ground. If the potential site met the site selection criteria then it is marked on the topographic map as a site. During the site selection, the profile data was viewed to check for a radiometric high with a low gradient at the site.

The sites were selected to ensure that the sensitivities were calculated with minimum error. Each of the sites was located on the ground directly below a flight line of the airborne survey and selected based on the criteria explained in detail below in site selection. At each site four readings were taken to determine the local variation in the ground concentrations at the site. The four readings were scattered about the site in a 50m radius. The average of these four ground readings at this site was then compared to the average of the airborne data (cps) within 250m of the ground site. This comparison determined the sensitivities at this site for each of the radio-elements and total count .This was done for all twenty sites and a weighted average of all the sites was used to calculate the sensitivity for the survey. The survey data was then converted into ground concentrations by dividing the airborne data by these sensitivities.

Complete details of the ground data collection methods, using the spectrometer to take a reading, the processing of the field data and the calculation of the sensitivities are included in Annex B: Ground Spectrometer Operation and Calculations for use in Back-Calibration.

Annex C: Sample Calculations of Sensitivity Coefficient contains all the data for one survey that was back-calibrated and processed to calculate the Sensitivity Coefficients (T.C., U, K, Th) to

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correct airborne data from counts per second to ground concentrations.

3.iv) Site Selection Criteria

The back-calibration sites were selected based on the following criteria:

a) Flat Topography

An area of high topographic relief presents two possible problems that may create large errors in the back-calibration. In areas of high relief it is difficult for the aircraft to maintain a constant altitude above the ground. Therefore, the attenuation constant and height correction that were used to process the data become much more suspect in an area of high topographic relief as opposed to a flat topographic area. The erosion on slopes, especially in tropical areas is great. The high relief areas become "radioactively unstable" where the radioactive material in the ground is more easily eroded than in flat areas. This may present the problem of local anomalies due to erosion which may make it difficult to get an accurate ground concentration reading.

b) Active Radioactive Response

Selecting an area that is radioactively high is important in minimizing the error in the back-calibration sensitivity calculation. Radiometric measurements are a statistical method, so the higher the counts in both the ground and the air the lower the statistical error will be.

c) Low Gradient Area

To select an area where the airborne data has a low gradient is important for several reasons. The exact location of the ground site becomes less critical in a low gradient area. Also there are less likely to be local variations in the ground concentration readings therefore the ground readings should have a lower error.

d) Clear Area

Vegetation cover may attenuate the gamma-rays which will reach the plane during the surveying. Therefore the airborne data over a forested area will be lowered. The amount of attenuation cannot be accurately calculated, causing the sensitivities calculated in a forested area to be incorrect.

e) Good Accessibility

Approximately 20 sites at various locations around the survey area are required to do an effective back-calibration. Since the sites are carefully selected to meet the back-calibration site criteria they may be many miles apart. To make the back-calibration as efficient as possible sites were selected that were easily accessible by major roads whenever possible.

f) Accurate Ground Location

It is important to select sites that are easily located on a map and in the field. The ground data must be matched with the airborne data. If the site is at an easily identifiable point on the map then it is most likely that the airborne data was properly located at this point(it cannot be assumed that all the airborne data is exactly located since it was mostly visually located). Likewise if the site is easily located in the field it will reduce the site location error for the ground readings.

g) Dry Area

Selecting a dry area to do the back-calibration will make the back-calibration more accurate with less delays. Ground that is wet after rain will not give an accurate gamma-ray reading. Therefore after a rain no surveying should be done until the ground has had a chance to dry. There is no guarantee that this was done when the survey data was collected, so in an arid area it is less likely that this will cause error. Also an arid area will mean less delays due to rain.

3.iv) Back-Calibration Calculations

For each site, all the airborne data points on a line that are within a 250m distance of the ground sites were averaged and the errors calculated (for each of the three elements and the total count). The average was calculated for each of potassium, uranium, thorium and total count using the formula:

$$mean_{air} = \frac{\sum counts}{nfids}$$

where:

$mean_{air}$ is the average of the airborne counts at this back-calibration site

counts is the counts at each of the airborne data points

nfids is the number of airborne data points used in the average

The error was calculated to indicate the amount of variation of the airborne data above the site. The error was calculated as standard deviation using the formula shown below:

Where:

$$error_{air} = [(\Sigma\ (counts)^2 - ((\Sigma\ counts)^2/nfids))/(nfids - 1)]^{1/2}$$

$error_{air}$ is the error calculated for the average of the airborne counts at this back-calibration site

counts is the counts at each of the airborne data points

nfids is the number of airborne data points used in the average

Once the airborne mean and error at each of the back-calibration sites was calculated, the ground concentration readings were averaged and their respective errors calculated. The total count concentration was derived from the ground concentration reading of potassium, uranium and

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thorium for each of the reading.

The total count concentration was given as the exposure rate (given in micro-Roentgen/hr) The formula used to calculate the exposure rate is given in the IAEA, Technical Report Series No. 323, Airborne Gamma Ray Spectrometer Surveying as:

$$E = 1.505K + 0.653eU + 0.287eTh$$

where

E is the exposure rate

K is the potassium concentration for the reading (given in % of potassium)

eU is the uranium concentration for the reading (equivalent uranium in ppm)

eTh is the thorium concentration for the reading (equivalent thorium in ppm)

The ground concentrations at each of the back-calibration sites was averaged and their respective errors calculated for each of the three elements and the total count using the formula:

$$mean_{ground} = \frac{\sum conc}{npts}$$

where:

$mean_{ground}$ is the average of the ground concentration reading at each of the back-calibration sites

conc is the concentrations for each of the readings

npts is the number of reading that were taken at each of the sites

The error for the ground concentration was calculated as standard deviation and indicated the variation in the ground concentration readings.

where:

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$$\text{error}_{\text{ground}} = [(\Sigma \text{ conc})^2 - ((\Sigma \text{ conc})^2/\text{npts}))/\text{npts}-1)]^{1/2}$$

error $_{ground}$ is the error calculated for the ground concentration at each of the back-calibration sites

conc is the concentrations for each of the readings

npts is the number of reading that were taken at each of the sites

The sensitivities for potassium, uranium, thorium and total count at each of the sites were then calculated by dividing the average airborne counts (cps) by the average ground concentration.

Where:

$$\text{sens} = \text{mean}_{\text{air}} / \text{mean}_{\text{ground}}$$

sens is the sensitivity calculated at each of the sites

mean $_{air}$ is the average of the airborne counts at each back-calibration site

mean $_{ground}$ is the average of the ground concentration reading at each of the back-calibration sites

The error for the sensitivity calculated was determined as shown below.

$$error_{sens} = \left[\frac{error_{ground}^2}{mean_{ground}^2} + \frac{error_{air}^2}{mean_{air}^2} \right]^{1/2} \cdot sens$$

where:

sens is the sensitivity calculated at each of the sites

error $_{sens}$ is the error calculated for the sensitivities at each of the sites

error $_{ground}$ is the error calculated for the ground concentration at each of the back-calibration sites

error $_{air}$ is the error calculated for the average of the airborne counts at this back-

calibration site.

Once the sensitivities and their respective errors were calculated for each site for each of the three elements and total count, the sensitivities for the survey were calculated. A weighted average of the sensitivities at each of the sites was used to calculated the sensitivities for the survey. The weighting was based on the error. The formulas used are shown below:

$$fsens = \sum (\text{sens}/\text{error}^{2}_{\text{sens}}) / \sum (\text{error}_{\text{sens}})^{-2}$$

$$\text{error}_{fsens} = [1/\sum (\text{error}_{\text{sens}})^{-2}]^{1/2}$$

where:

fsens is the weighted averaged sensitivity for the survey

sens is the sensitivity calculated at each of the sites

$error_{sens}$ is the error calculated for the sensitivities at each of the sites

$error_{fsens}$ is the error calculated for the sensitivities of the survey

The sensitivities calculated were directly applied to the six back-calibrated surveys to convert them from cps to ground concentrations. These sensitivities were then applied to the other surveys in the groups with some adjustments to the sensitivities. It was possible to calculate the adjustments to the sensitivities based on the differences in the survey specifications such as spectral window size and stripping ratios.

4) DATA PRODUCTS AND FORMATS:

For each radioelement, for each survey, the following final products were generated, and have been written to CD:

4.i) Profile data archive, in Geosoft XYZ format, with the following structure:

Channel	Data
1	Easting (Equatorial Mercator Projection)
2	Northing (Equatorial Mercator Projection)
3	Raw Radioelement counts
4	Easting (Universal Transverse Mercator Projection)
5	Northing (Universal Transverse Mercator Projection)
6	Levelled Radioelement counts
7	Radioelement concentration

4.ii) A grid of radioelement concentration at optimum cell size, (i.e. 1/4 flight line spacing), in Geosoft 2 byte integer format.

4.iii) Where appropriate, a supergrid linking adjacent surveys, at a 500 m cell size, in Geosoft 2 byte integer format.

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5) BARMP SURVEY ATLAS

5.i) BRAZIL AIRBORNE RADIOMETRIC MAPPING PROJECT SURVEY

The following pages contain all pertinent specifications for digital surveys that have been included in BARMP, including;

Project Name

Client Name

Contractor

Survey Year

Survey Specifications

Back-Calibration Sensitivities

Window Sizes

Stripping Ratios

Comments

The survey locations have been taken from the final completed radioelement grids.

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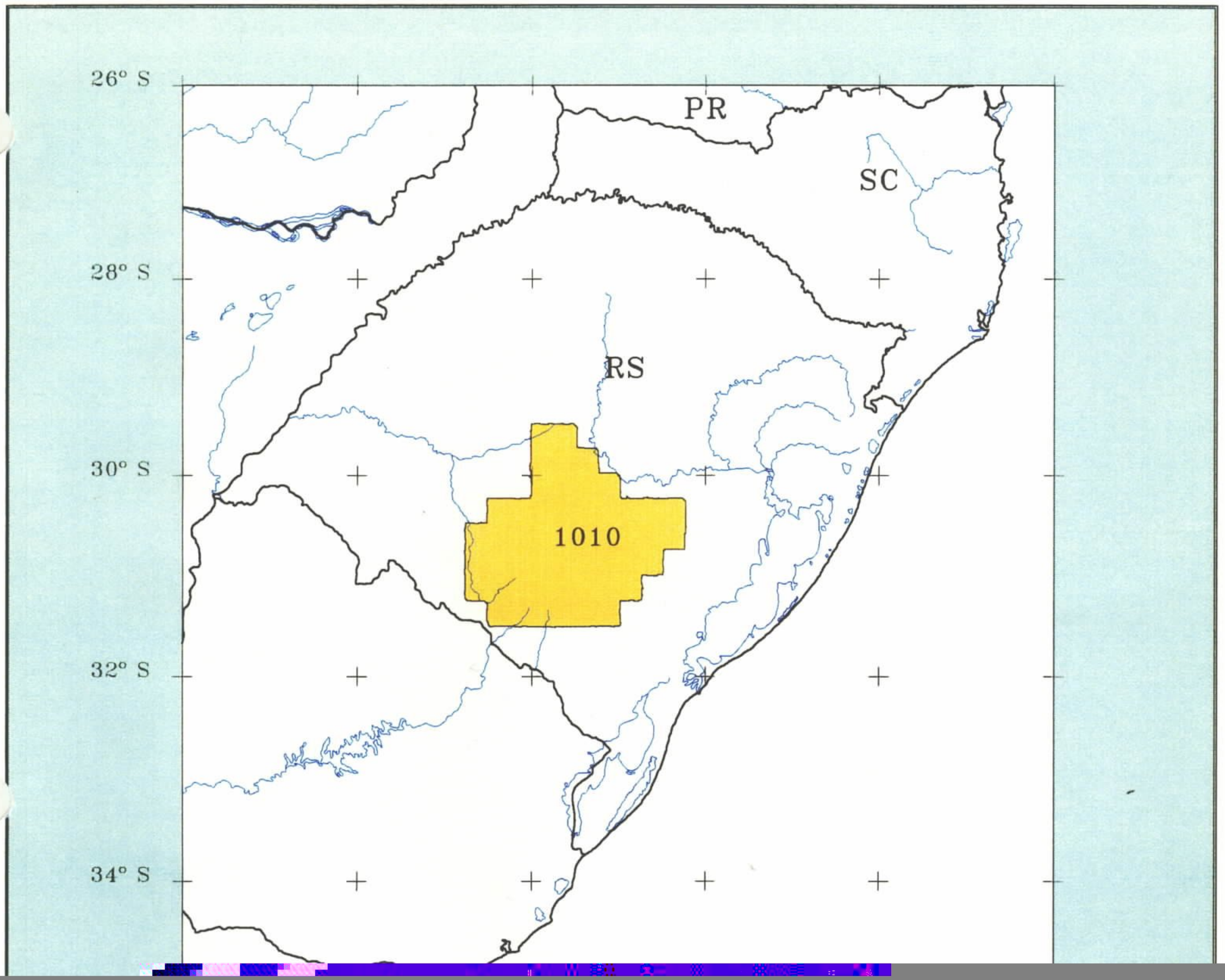
5.ii) OTHER KNOWN SURVEYS

The following two surveys are known to exist at CPRM:

1) Project Furnas - Survey #2015, CNEN
2) Project Basic/Ultrabasic, Rocks de Vitória da Conquista - Survey # 3005, CPRM

The details for these two surveys have been included, for reference, in the Survey Atlas.


26° S
28° S
30° S
32° S
34° S
PR
SC
RS
1010

SAMMP # **4028** *CPRM #* **1010**

Project **Camaquã (Area 1)**
Client: **Departamento Nacional da Produção Mineral-DNPM/CNEN**
Contractor: **Texas Instruments**
Survey Completion Year: **1973**

Number of Sub-Areas: 1
Total Area (km²): 33 906
Line km: 36 763
Flight Direction: NW-SE
Line Spacing (km): 1
Tie Line Spacing (km): 18
Flight Altitude (mtc) (m): 150
Gamma-Spectrometer: Texas Instrument
Crystal Volume (in³): 2491.59
Type of Aircraft: DC-3

Back-Calibrated Sensitivities

Thorium(Th) (cps/ppm): 12.9
Potassium(K) (cps/%): 203.8
Uranium(U) (cps/ppm): 23.3
Total Count(Tc) (cps/dose rate): 498

Window Sizes

Thorium(Th) (MeV): 2.41 - 2.81
Uranium(U) (MeV): 1.66 - 1.86
Potassium(K) (MeV): 1.36 - 1.56
Total Count(Tc) (MeV):

Stripping Ratios

Alpha:
Beta:
Gamma:

Comments: -

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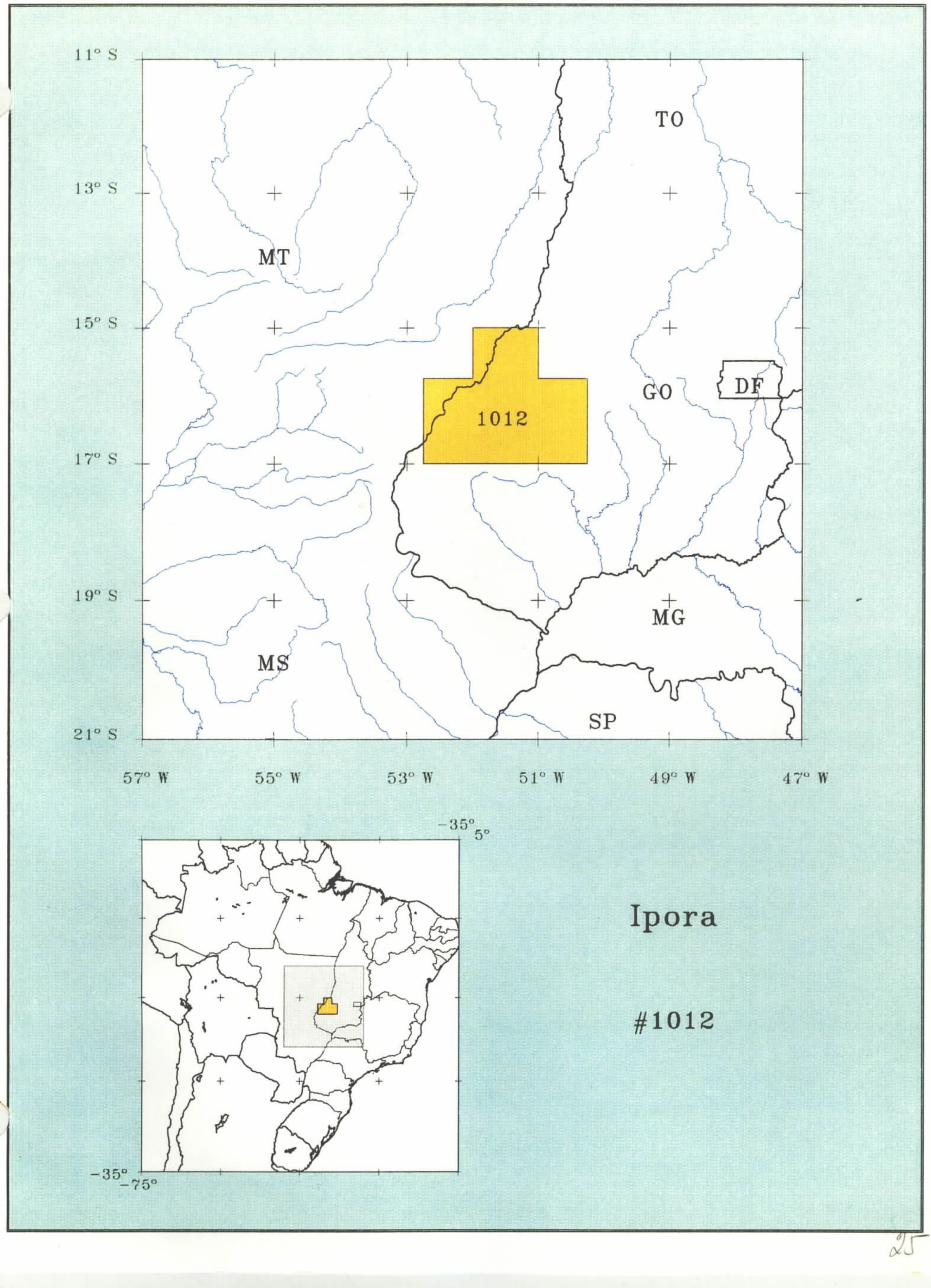
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5°
-35°
-75°

Ipora

#1012

SAMMP #	**4060**	***CPRM #***	**1012**

Project	**Iporá**
Client:	**Departamento Nacional da Produção Mineral-DNPM/CNEN**
Contractor:	**PROSPEC**
Survey Completion Year:	**Unknown**

Number of Sub-Areas:	1
Total Area (km²):	46 000
Line km:	48 570
Flight Direction:	N-S
Line Spacing (km):	1
Tie Line Spacing (km):	22.5
Flight Altitude (mtc) (m):	150
Gamma-Spectrometer:	Hammer-Harshaw
Crystal Volume (in³):	415.26
Type of Aircraft:	Aero Commander

<u>Back-Calibrated Sensitivities</u>

Thorium(Th) (cps/ppm):
Potassium(K) (cps/%):
Uranium(U) (cps/ppm):
Total Count(Tc) (cps/dose rate):

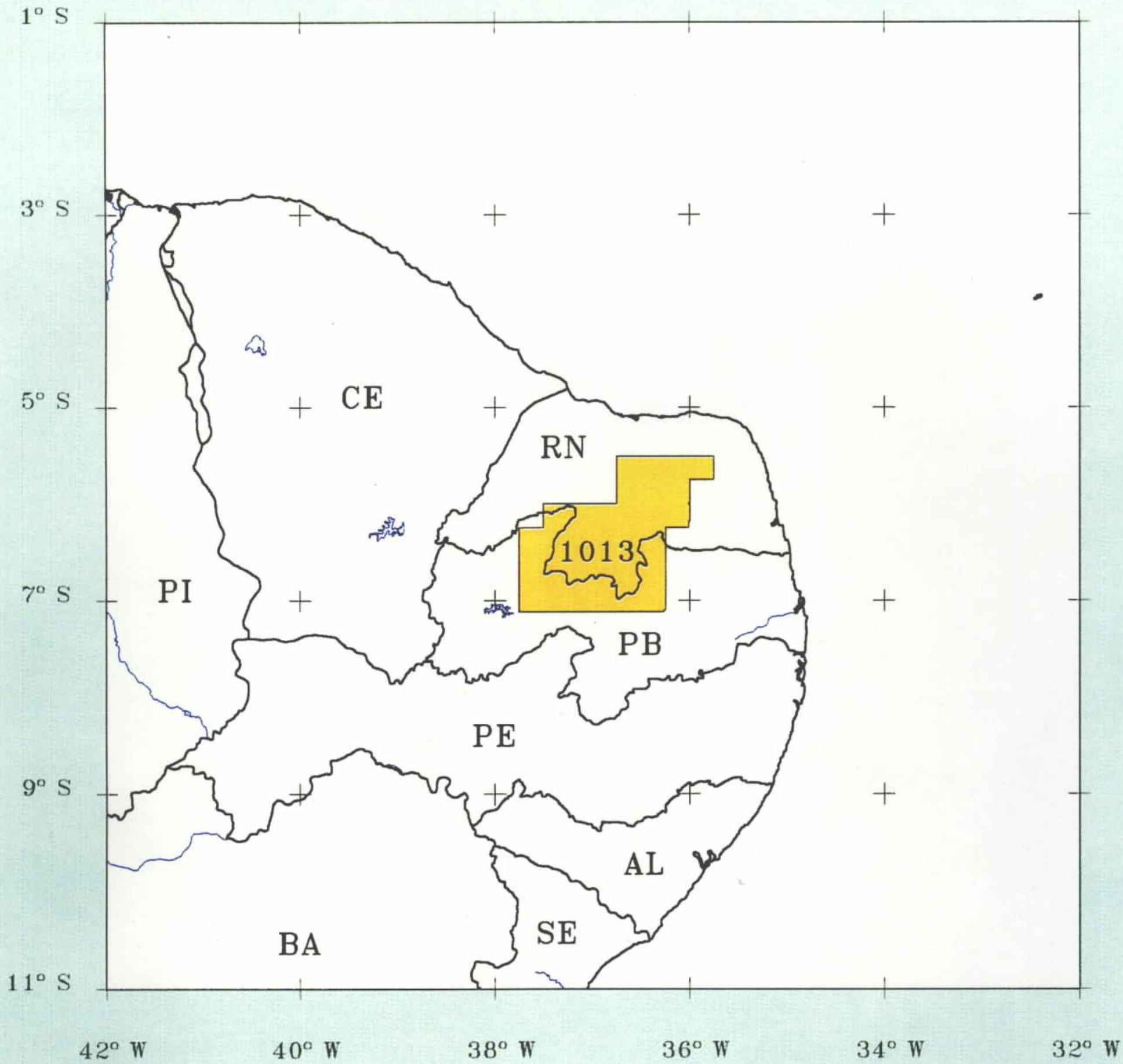
<u>Window Sizes</u>

Thorium(Th) (MeV): ***Uranium(U) (MeV):***
Potassium(K) (MeV): ***Total Count(Tc) (MeV):***

<u>Stripping Ratios</u>

Alpha: ***Beta:***
Gamma:

Comments: Total count grids generated from digitized Total Count profiles. Survey was not back-calibrated.



Serido

#1013

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SAMMP #	**4070**	***CPRM #***	**1013**

Project	**Seridó**
Client:	**Departamento Nacional da Produção Mineral-DNPM/CNEN**
Contractor:	**LASA**
Survey Completion Year:	**1973**

Number of Sub-Areas:	1
Total Area (km²):	25 000
Line km:	28 000
Flight Direction:	E-W
Line Spacing (km):	1
Tie Line Spacing (km):	20
Flight Altitude (mtc) (m):	135
Gamma-Spectrometer:	Exploranium DIGRS-2000
Crystal Volume (in³):	1012.5
Type of Aircraft:	DC-3

Back-Calibrated Sensitivities

Thorium(Th) (cps/ppm):
Potassium(K) (cps/%):
Uranium(U) (cps/ppm):
Total Count(Tc) (cps/dose rate):

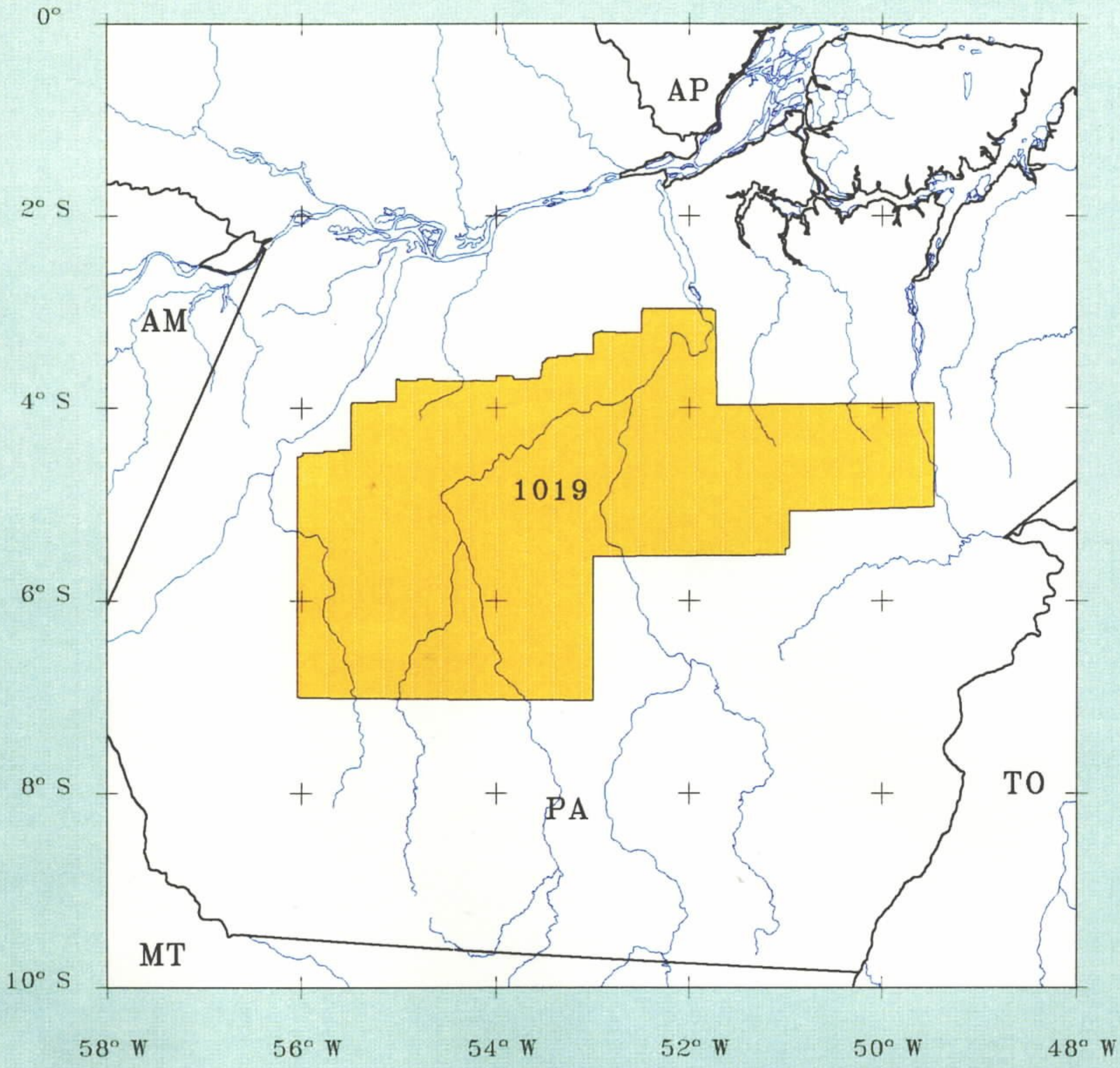
Window Sizes

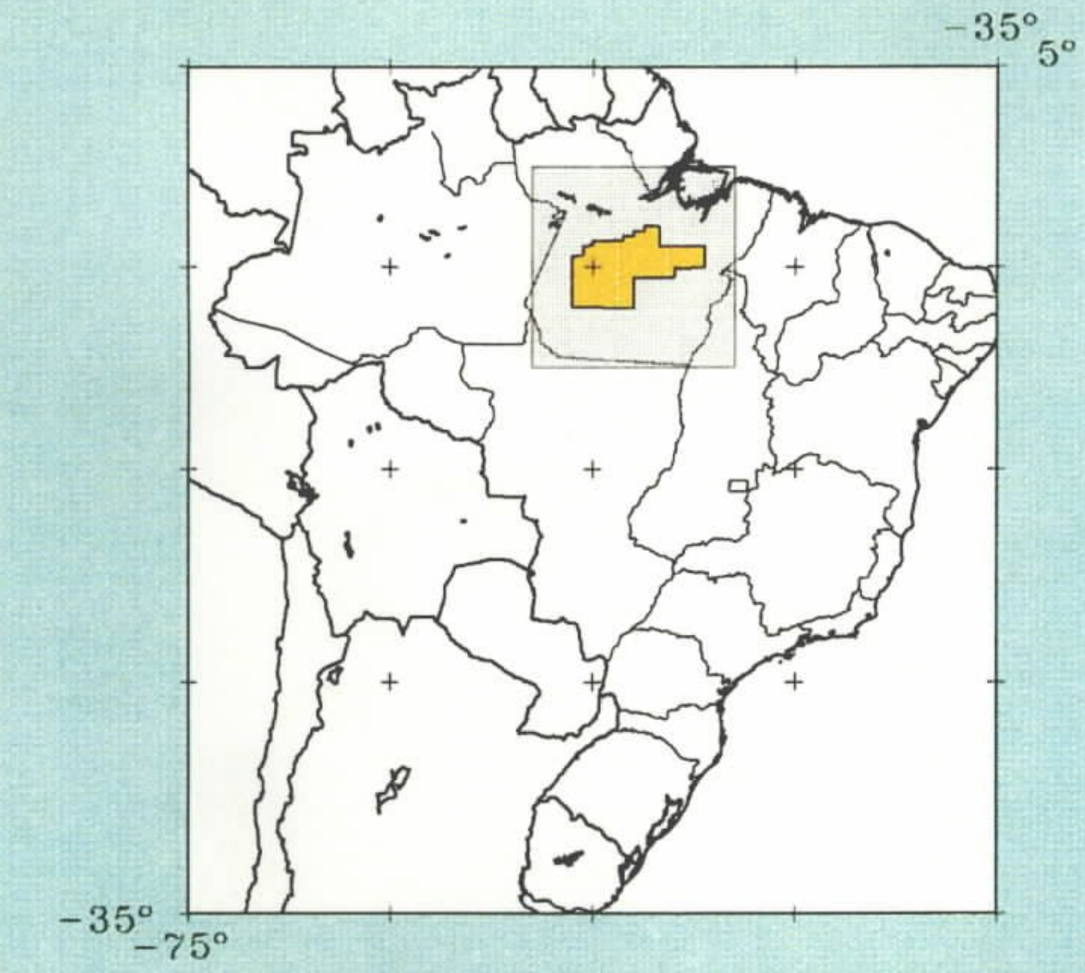
Thorium(Th) (MeV): ***Uranium(U) (MeV):***
Potassium(K) (MeV): ***Total Count(Tc) (MeV):***

Stripping Ratios

Alpha: ***Beta:***
Gamma:

Comments: Data obtained from digitized U, Th, K and Total Count profiles. Survey was not back-calibrated.





Sul do Para

#1019

SAMMP #	**4047**	***CPRM #***	**1019**

Project	**Sul do Para**
Client:	**Departamento Nacional da Produção Mineral-DNPM/NUCLEBRÁS**
Contractor:	**LASA**
Survey Completion Year:	**1976**

Number of Sub-Areas:	3
Total Area (km²):	165 000
Line km:	56 517
Flight Direction:	N-S
Line Spacing (km):	4
Tie Line Spacing (km):	20
Flight Altitude (mtc) (m):	150
Gamma-Spectrometer:	Exploranium DGRS-1000
Crystal Volume (in³):	1017.87
Type of Aircraft):	Islander (West) DC-3 (East)

Back-Calibrated Sensitivities

Thorium(Th) (cps/ppm):	2.0
Potassium(K) (cps/%):	112
Uranium(U) (cps/ppm):	10.07
Total Count(Tc) (cps/dose rate):	64

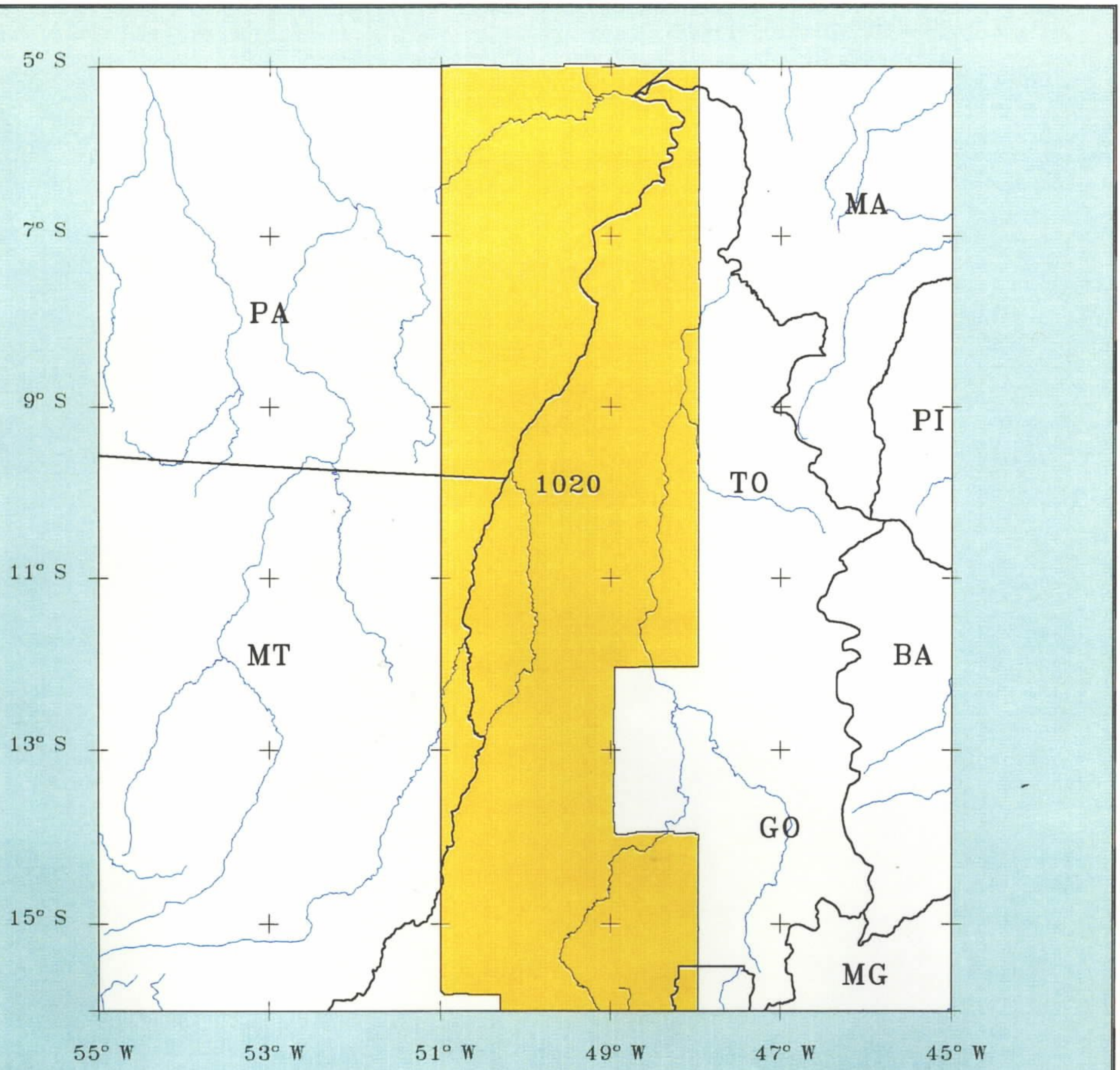
Window Sizes

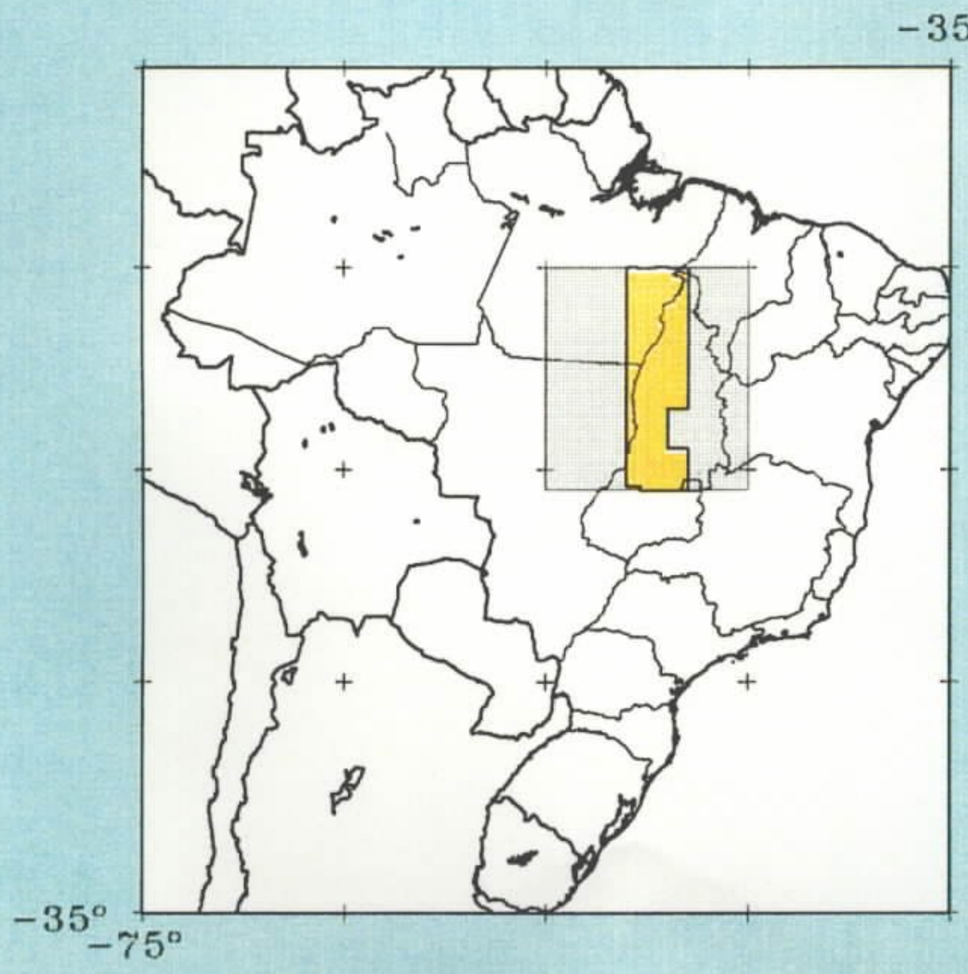
Thorium(Th) (MeV):	2.42 - 2.82	***Uranium(U) (MeV):***	1.66 - 1.86
Potassium(K) (MeV):	1.36 - 1.56	***Total Count(Tc) (MeV):***	0.4 - 2.82

Stripping Ratios

Alpha:	0.365	***Beta:***	0.5
Gamma:	0.77		

Comments: Two types of aircraft used: DC-3 (east) and Islander (west).





Geofisico Brasil-Canada

#1020

SAMMP # **4025** ***CPRM #*** **1020**

Project: **Geofísico Brasil-Canadá**
Client: **Departamento Nacional da Produção Mineral-DNPM**
Contractor: **Northway Survey**
Survey Completion Year: **1976**

Number of Sub-Areas	3
Total Area (km^2):	375 000
Line km:	273 411
Flight Direction:	N-S
Line Spacing (km):	2
Tie Line Spacing (km):	14
Flight Altitude (mtc) (m):	150
Gamma-Spectrometer:	Scintrex GAD-5
Crystal Volume (in^3):	1077
Type of Aircraft:	DC-3

Back-Calibrated Sensitivities

Thorium(Th) (cps/ppm): **
Potassium(E)_ (cps/%): **
Uranium(U) (cps/ppm): **
Total Count(Tc) (cps/dose rate): **

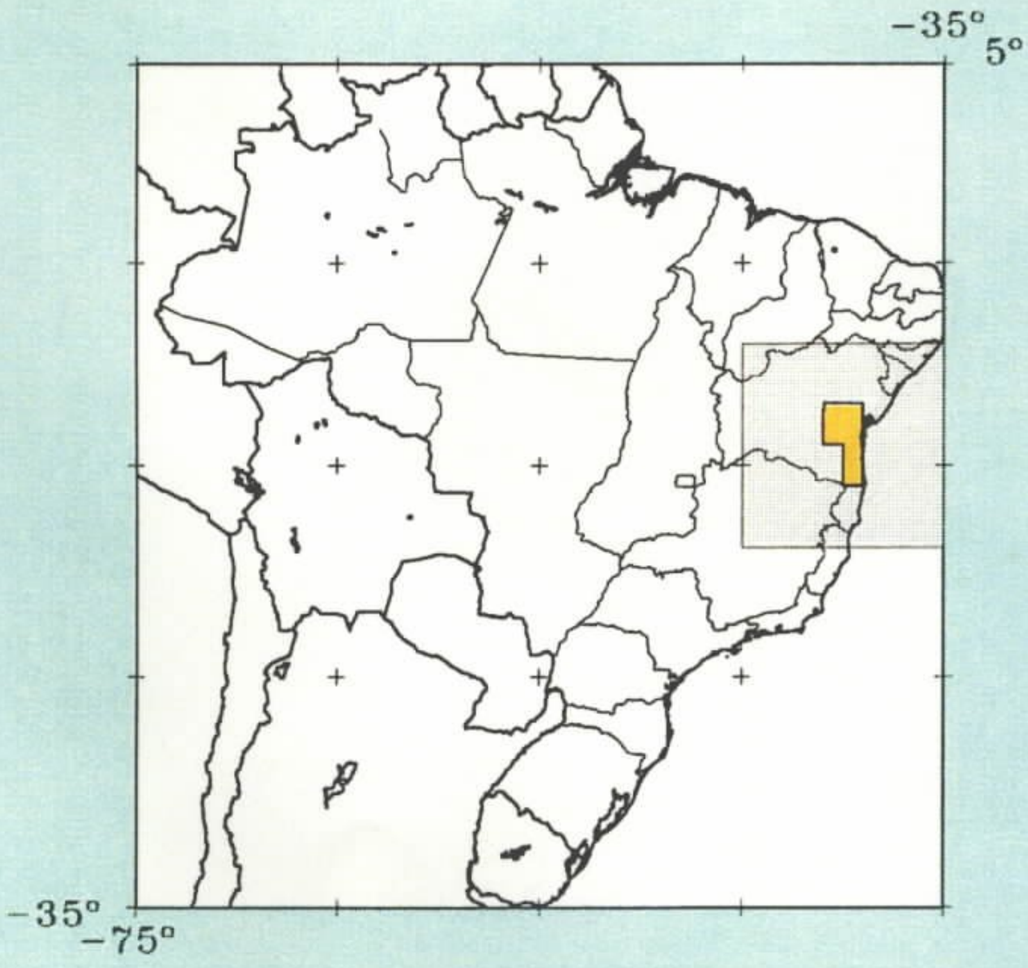
Window Sizes

Thorium(Th) (MeV): 2.42 - 2.82
Potassium(K) (MeV): 1.36 - 1.56
Uranium(U) (MeV): 1.66 – 1.86
Total Count(Tc) (MeV): 0.40 – 2.82

Stripping Ratios

Alpha: 0.34 0.425 0.46 0.379
Beta: 0.45 0.574 0.81 0.53
Gamma: 0.83 0.909 0.96 0.702

Comments: ** Supplied in ground concentration units, however values were considered inaccurate, therefore correction factor was applied to make the data fit with adjacent surveys. Th*8.7, U*17.9, Tc/20, and K not avail. Note 1: Some areas detailed at 1km line spacing. Note 2: Only grid data supplied to project. Grid cell sizes 800m for U and Th, and 2km for Total Count. No grid supplied for K.



Itaberaba–Belmonte

#1021

SAMMP #	**4076**	***CPRM #***	**1021**

Project	**Itaberaba-Belmonte**
Client:	**Departamento Nacional da Produção Mineral-DNPM**
Contractor:	**ENCAL S.A.**
Survey Completion Year:	**1976**

Number of Sub-Areas:	3
Total Area (km²):	72 000
Line km:	72 360
Flight Direction	N-S
Line Spacing (km):	1
Tie Line Spacing (km):	20
Flight Altitude (mtc) (m):	150
Gamma-Spectrometer:	Exploranium DIGRS-3001
Crystal Volume (in³):	1017.87
Type of Aircraft:	Islander

Back-Calibrated Sensitivities

Thorium(Th) (cps/ppm):	1.9
Potassium(K) (cps/%):	34.0
Uranium(U) (cps/ppm):	11
Total Count(Tc) (cps/dose rate):	40

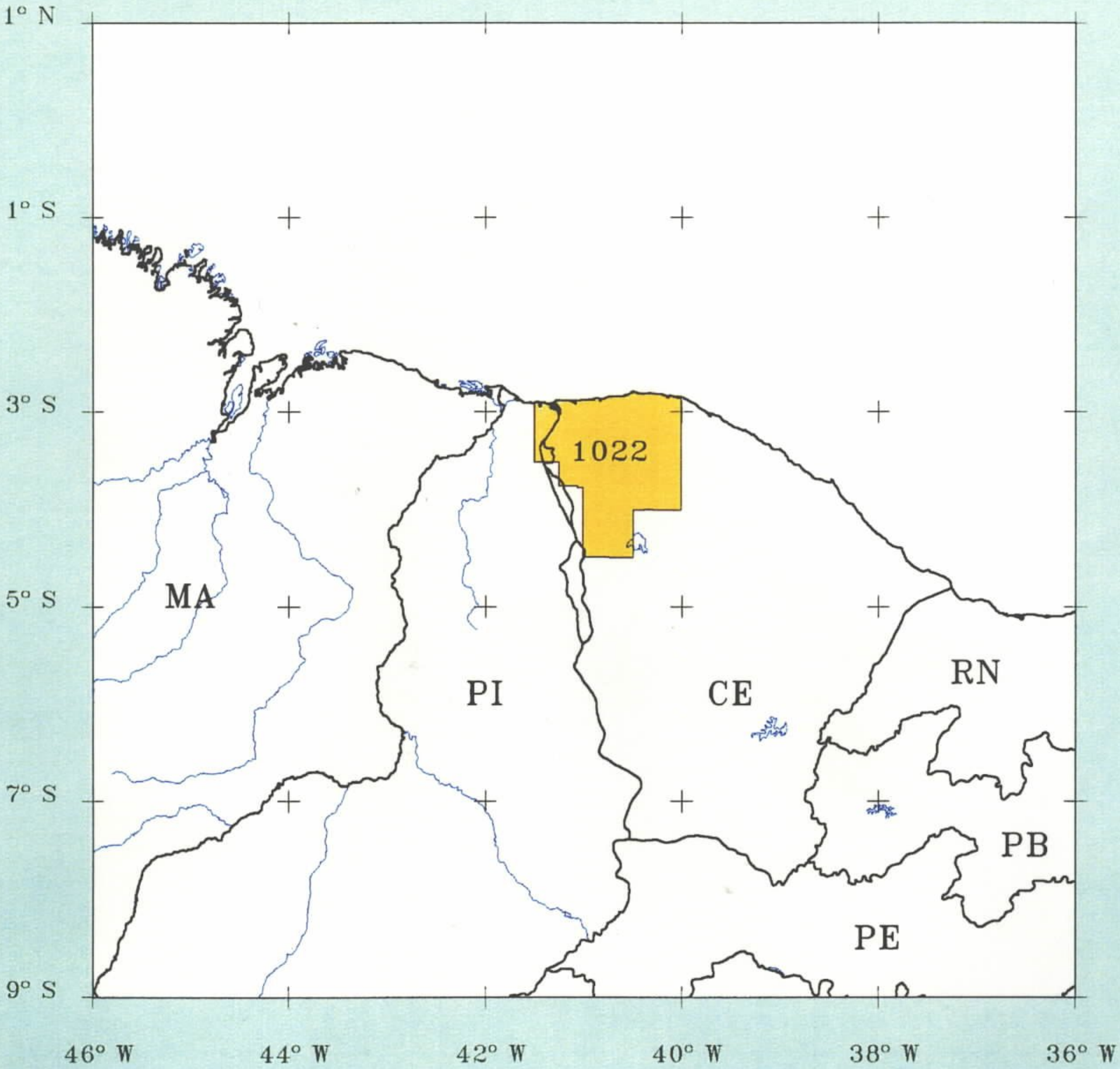
Window Sizes

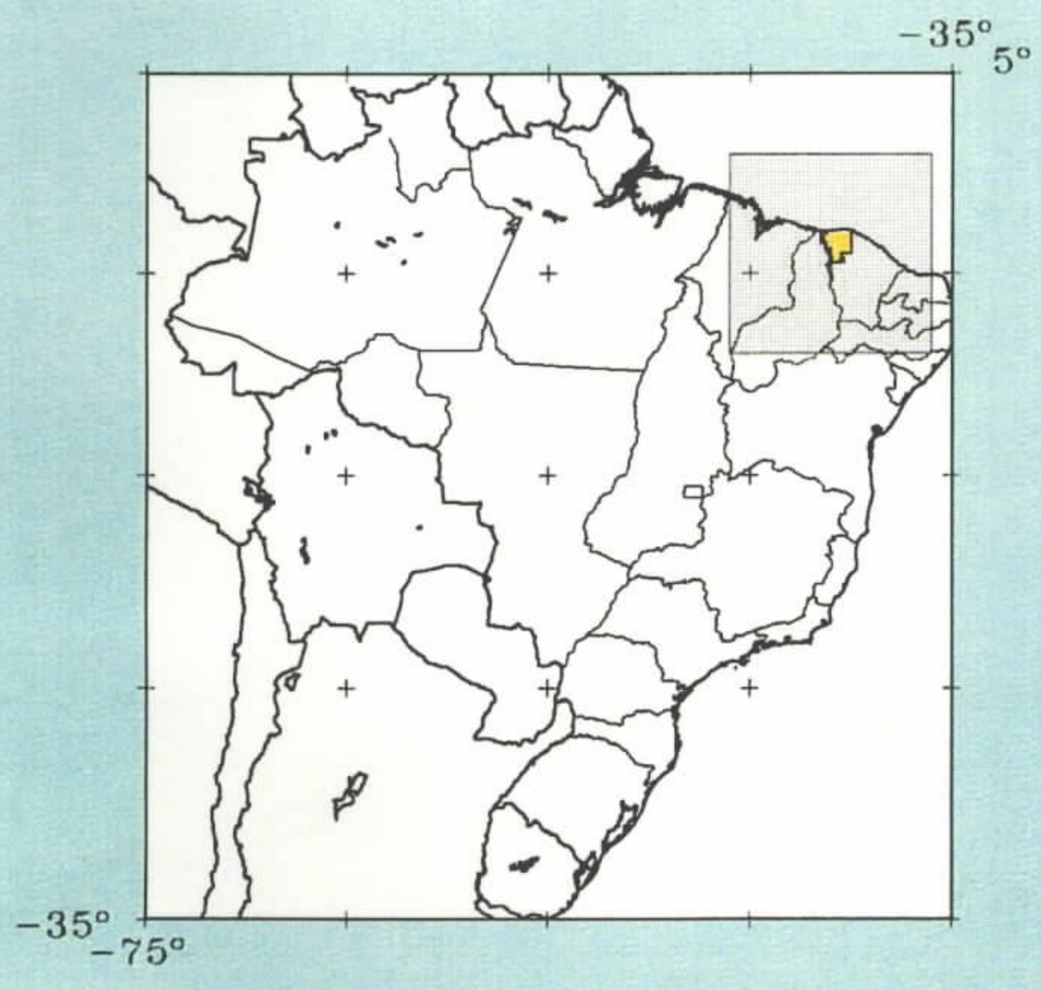
Thorium(Th) (MeV):	2.42 - 2.82	***Uranium(U) (MeV):***	1.66 - 1.86
Potassium(K) (MeV):	1.36 - 1.56	***Total Count(Tc) (MeV):***	0.4 - 2.82

Stripping Ratios

Alpha:	0.152 0.343 0.307	***Beta:***	0.387 0.479 0.618
Gamma:	0.833 1.048 0.752		

Comments: A base noise level in counts was removed from the data before applying the sensitivities. Th-22, U-30, Tc-1200.





Rio Acarau

#1022

SAMMP #	**4052**	***CPRM #***	**1022**

Project	**Rio Acarau**
Client:	**Departamento Nacional da Produção Mineral-DNPM**
Contractor:	**PROSPEC S.A.**
Survey Completion Year:	**1975**

Number of Sub-Areas:	1
Total Area (km²):	21 000
Line km:	23 720
Flight Direction:	N-S
Line Spacing (km):	1
Tie Line Spacing (km):	20
Flight Altitude (mtc) (m):	150
Gamma-Spectrometer:	Exploranium DIGRS-3001
Crystal Volume (in³):	830.94
Type of Aircraft:	Islander

Back-Calibrated Sensitivities

Thorium(Th) (cps/ppm): 2.04
Potassium(K) (cps/%): 30.0
Uranium(U) (cps/ppm): 7.6
Total Count(Tc) (cps/dose rate): 60.55

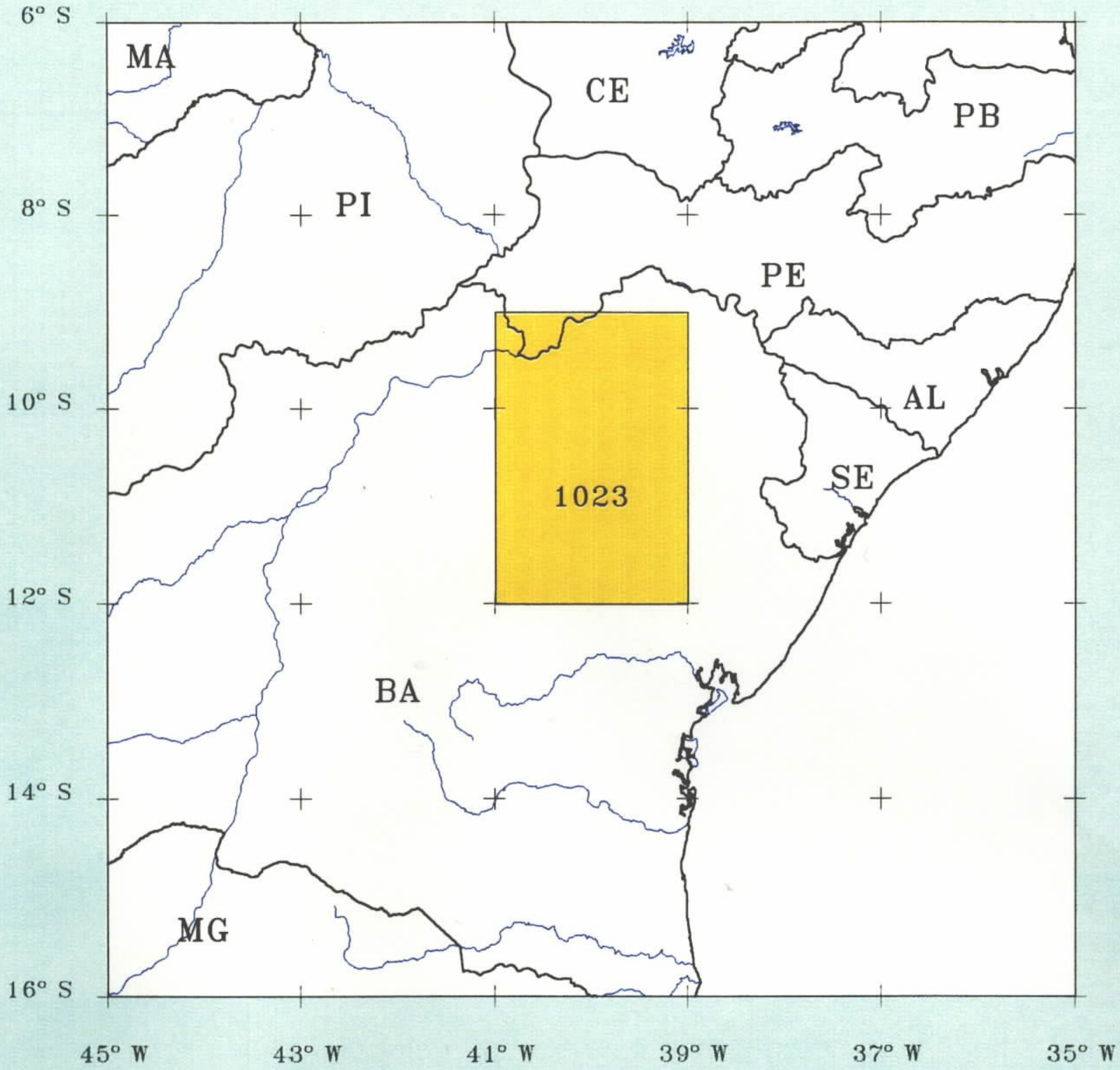
Window Sizes

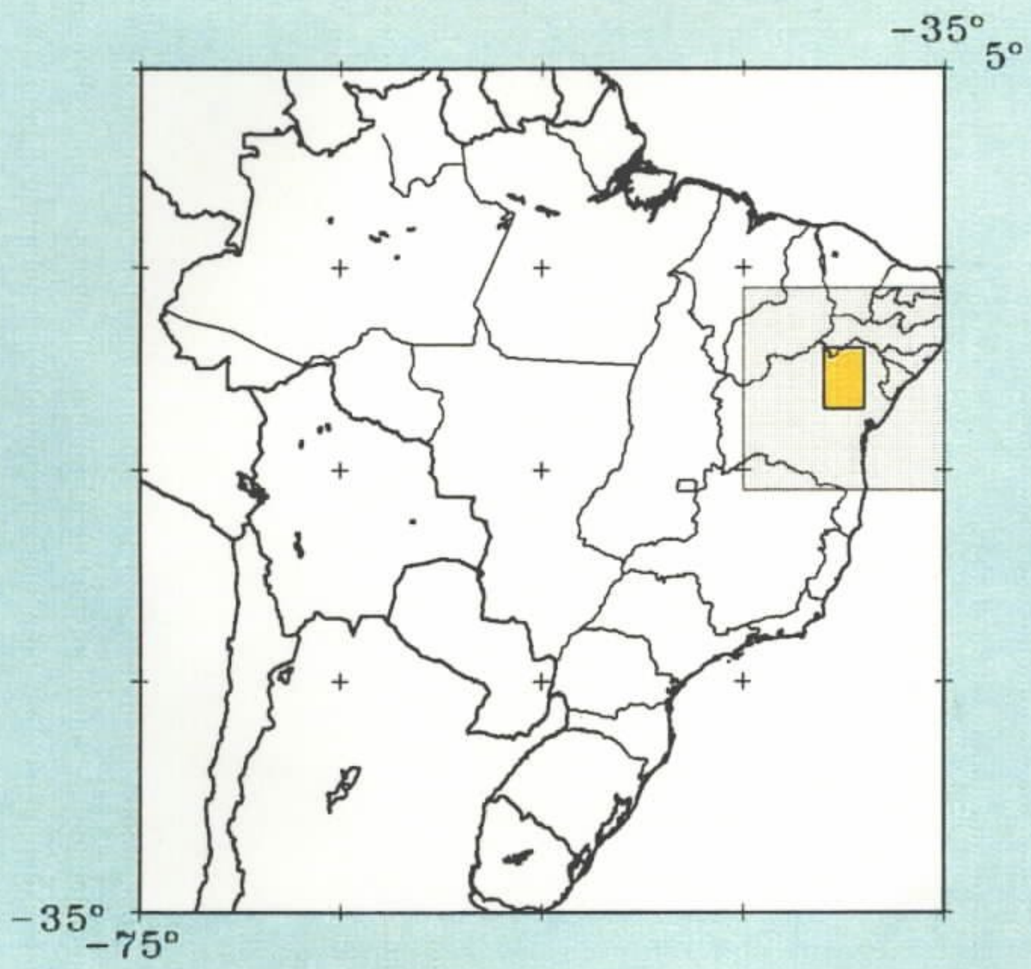
Thorium(Th) (MeV): 2.41 - 2.82
Uranium(U) (MeV): 1.66 - 1.86
Potassium(K) (MeV): 1.36 - 1.56
Total Count(Tc) (MeV): 0.78 - 2.82

Stripping Ratios

Alpha: 0.28
Beta: 0.35
Gamma: 0.83

Comments: -





Serra De Itiuba

#1023

SAMMP #	**4077**	***CPRM #***	**1023**

Project	**Serra de Itiúba**
Client:	**Departamento Nacional da Produção Mineral-DNPM**
Contractor:	**PROSPEC S.A.**
Survey Completion Year:	**1976**

Number of Sub-Areas:	2
Total Area (km²):	72 000
Line km:	76 531
Flight Direction:	NW-SE
Line Spacing (km):	1
Tie Line Spacing (km):	20
Flight Altitude (mtc) (m):	135
Gamma-Spectrometer:	Exploranium DIGRS-3001
Crystal Volume (in³):	830.94
Type of Aircraft:	Islander

Back-Calibrated Sensitivities

Thorium(Th) (cps/ppm): 2.70
Potassium(K) (cps/%): 34.52
Uranium(U) (cps/ppm): 6.5
Total Count(Tc) (cps/dose rate): 155.0

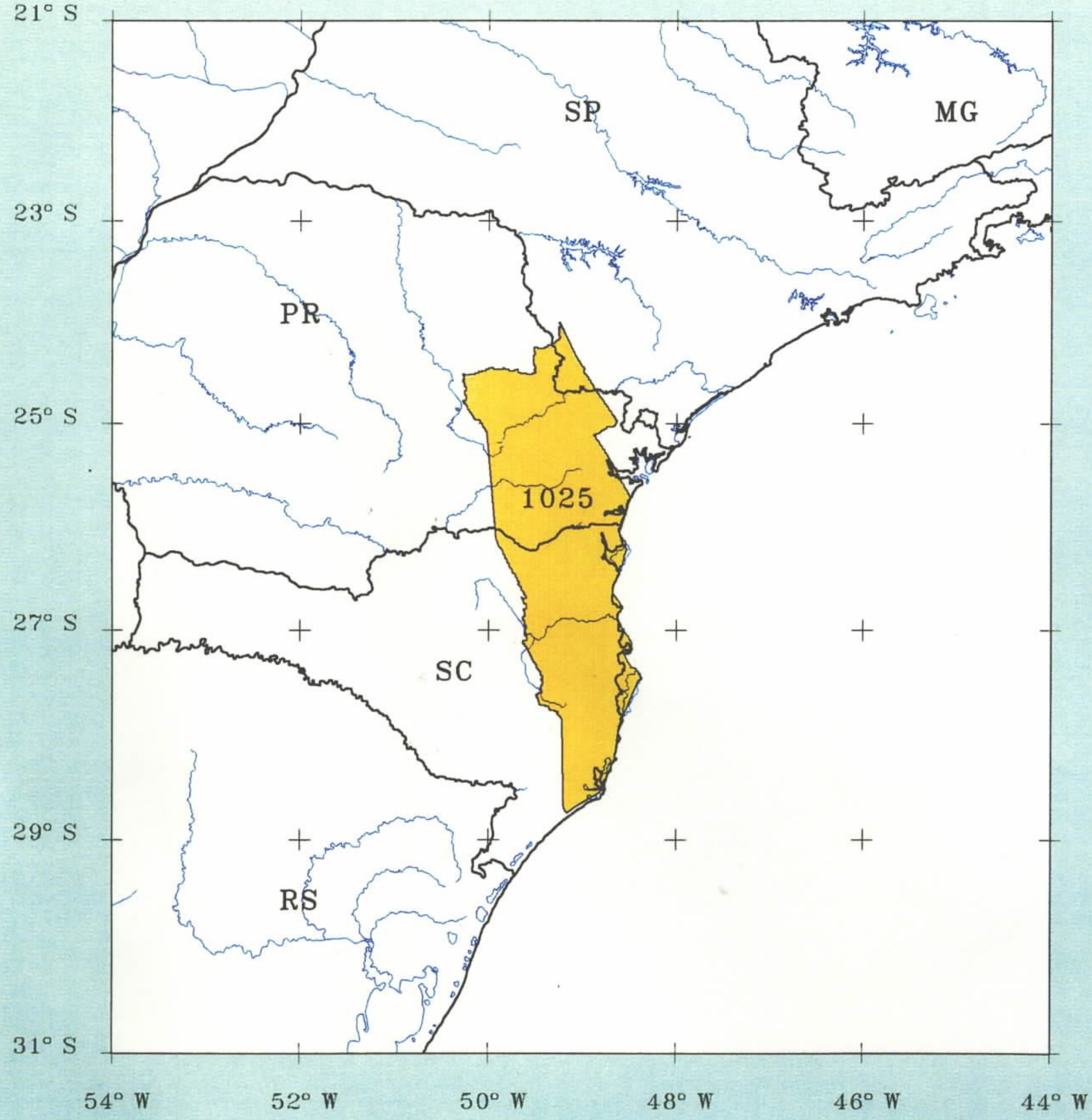
Window Sizes

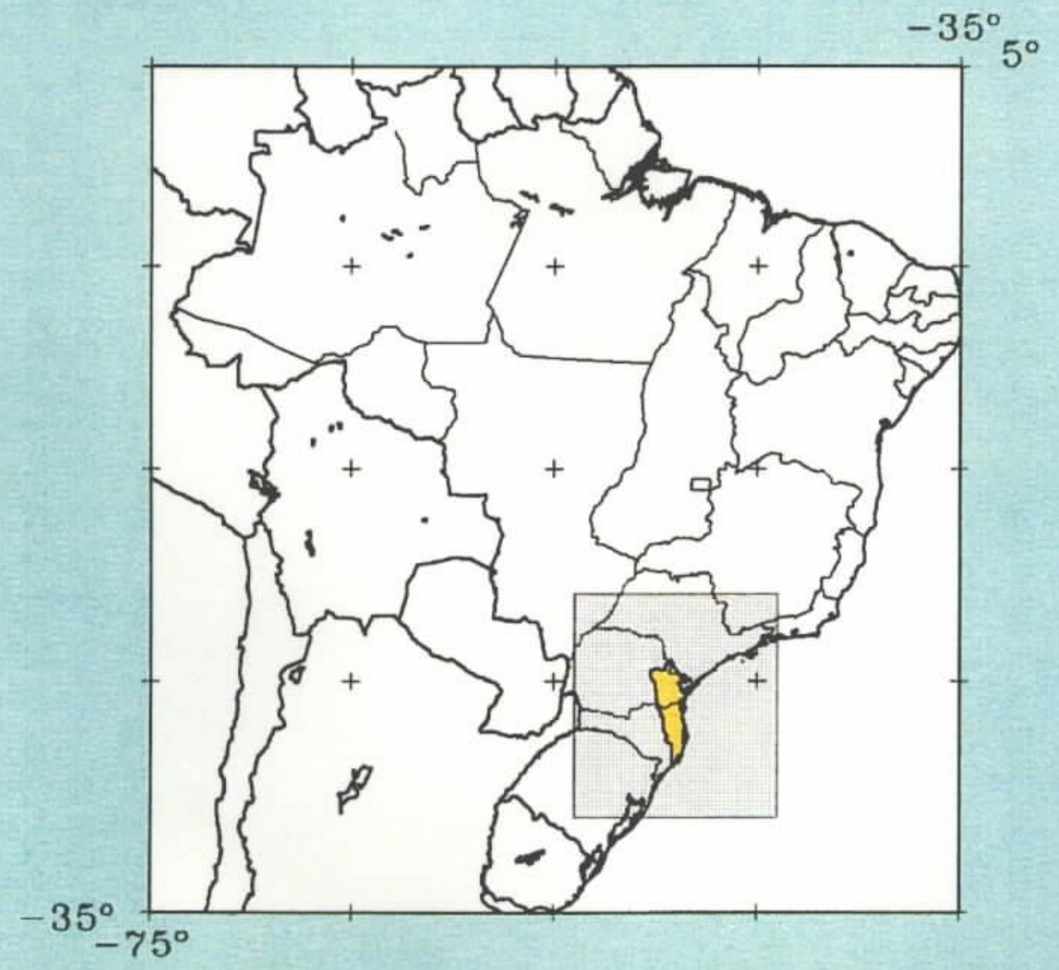
Thorium(Th) (MeV): 2.41 - 2.80
Uranium(U) (MeV): 1.66 - 1.86
Potassium(K) (MeV): 1.36 - 1.56
Total Count(Tc) (MeV): 0.78 - 2.82(1) 0.30 - 2.82(2)

Stripping Ratios

Alpha: 0.28(1) 0.500(2)
Beta: 0.35(1) 0.786(2)
Gamma: 0.83(1) 0.121(2)

Comments: (1) Stabilized on cesium (2) Stabilized on cobalt. Survey report does not indicate which survey lines were flown with each of (1) and (2).





Serra Do Mar Sul

#1025

SAMMP # 4029 *CPRM #* **1025**

Project	**Serra do Mar Sul**
Client:	**Departamento Nacional da Produção Mineral-DNPM**
Contractor:	**GEOFOTO**
Survey Completion Year:	**1977**

Number of Sub-Areas:	1
Total Area (km²):	48 600
Line km:	49 880
Flight Direction:	N30W
Line Spacing (km):	1
Tie Line Spacing (km):	20
Flight Altitude (mtc) (m):	150
Gamma-Spectrometer:	Exploranium DIGRS-3001
Crystal Volume (in³):	1017.87
Type of Aircraft:	Islander

Back-Calibrated Sensitivities

Thorium(Th) (cps/ppm): 1.78
Potassium(K) (cps/%): 25.88
Uranium(U) (cps/ppm): 10.07
Total Count(Tc) (cps/dose rate): 51.79

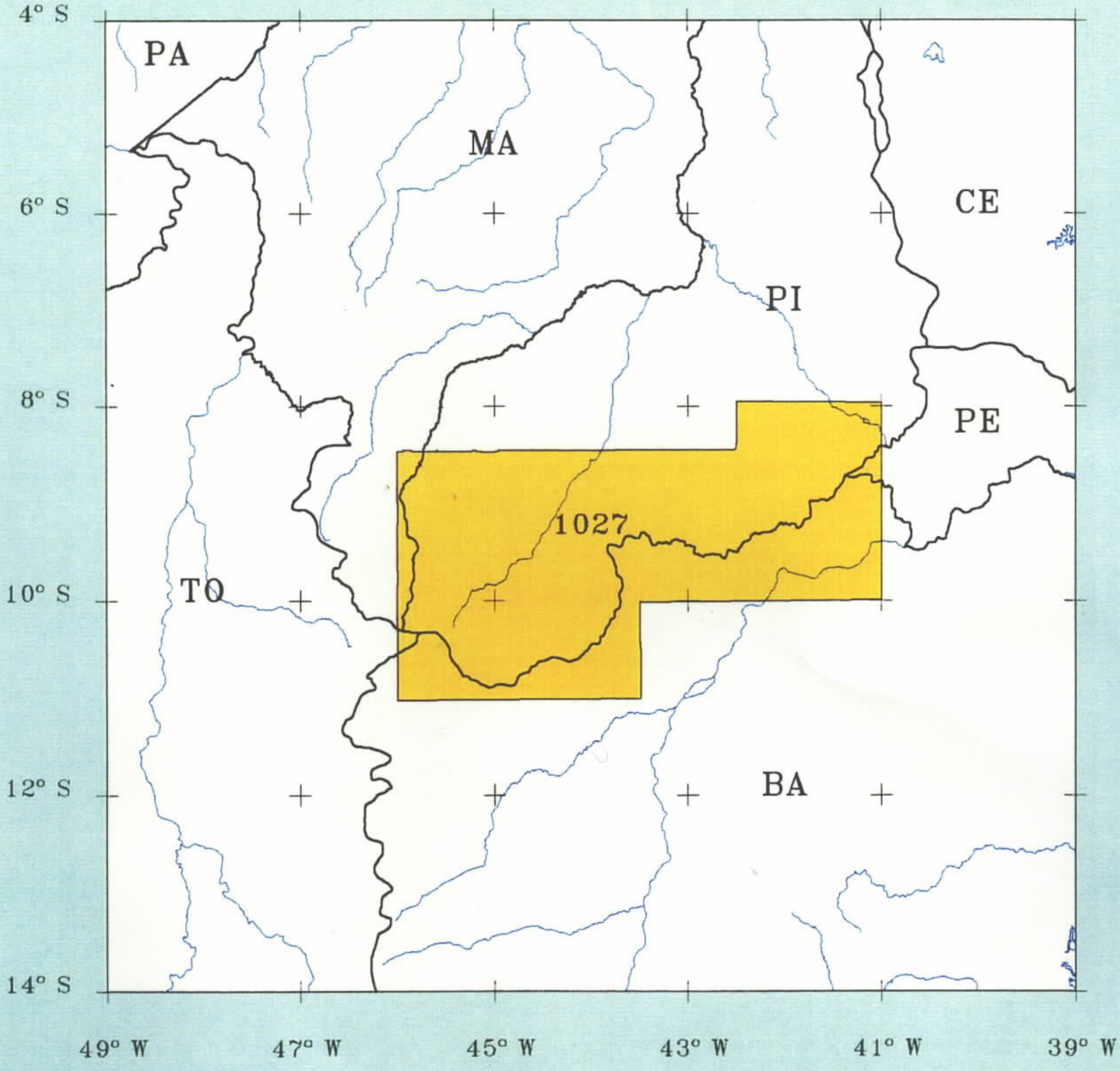
Window Sizes

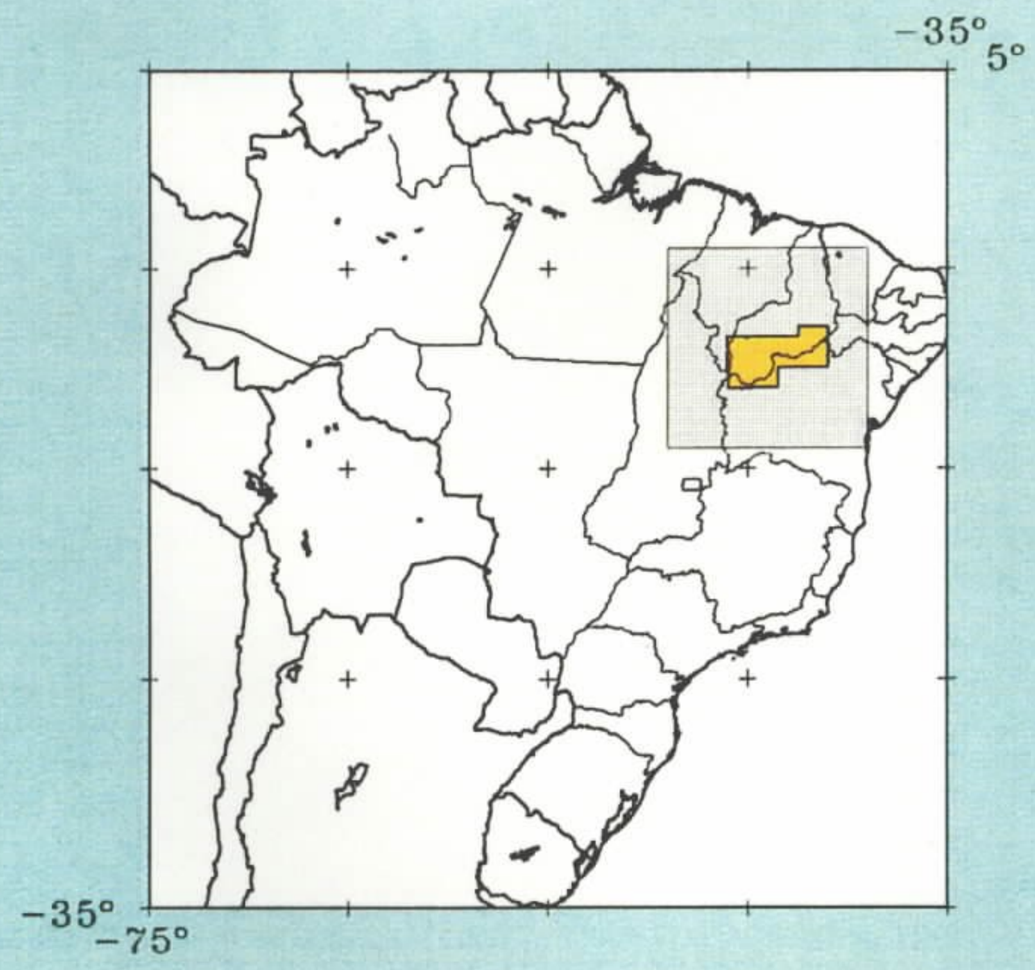
Thorium(Th) (MeV): 2.3 - 2.9
Uranium(U) (MeV): 1.65 - 2.3
Potassium(K) (MeV): 1.35 - 1.65
Total Count(Tc) (MeV): 1.0 - 2.9

Stripping Ratios

Alpha: 0.365
Beta: 0.5
Gamma: 0.77

Comments:





Borda Sul Da Bacia Do Parnaiba

#1027

SAMMP #	**4080**	***CPRM #***	**1027**

Project	**Borda Sul da Bacia do Parnaiba**
Client:	**Departamento Nacional da Produção Mineral-DNPM**
Contractor:	**PROSPEC**
Survey Completion Year:	**1977**

Number of Sub-Areas:	1
Total Area (km²):	131 000
Line km:	71 620
Flight Direction:	N-S
Line Spacing (km):	2
Tie Line Spacing (km):	20
Flight Altitude (mtc) (m):	150
Gamma-Spectrometer:	Exploranium DIGRS-3001
Crystal Volume (in³):	830.94
Type of Aircraft:	Islander

Back-Calibrated Sensitivities

Thorium(Th) (cps/ppm):	2.70(1)	2.70(2)
Potassium(K) (cps/%):	31.0(1)	31.0(2)
Uranium(U) (cps/ppm):	5.26(1)	8.42(2)
Total Count(Tc) (cps/dose rate):	60.55(1)	150.0(2)

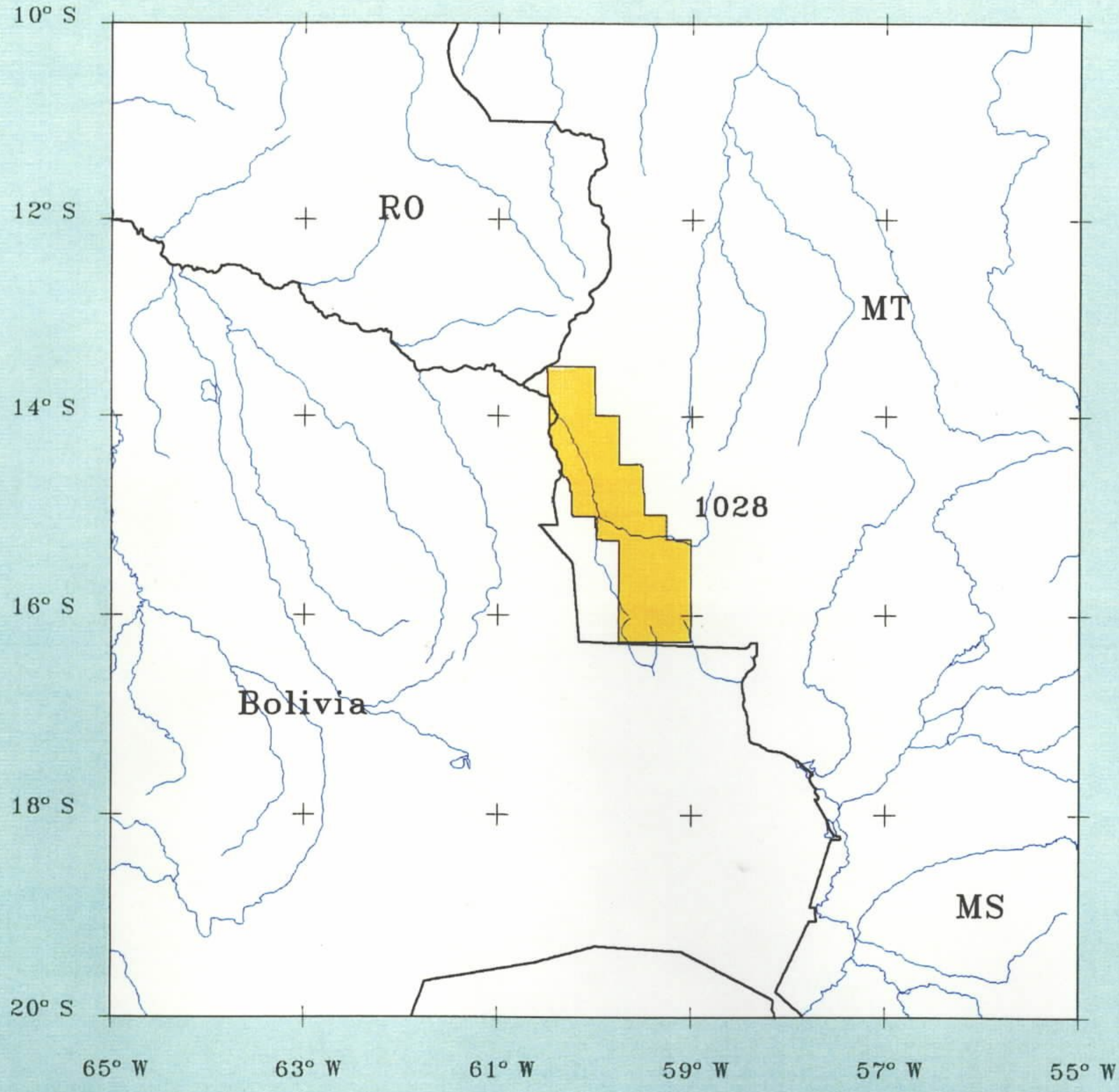
Window Sizes

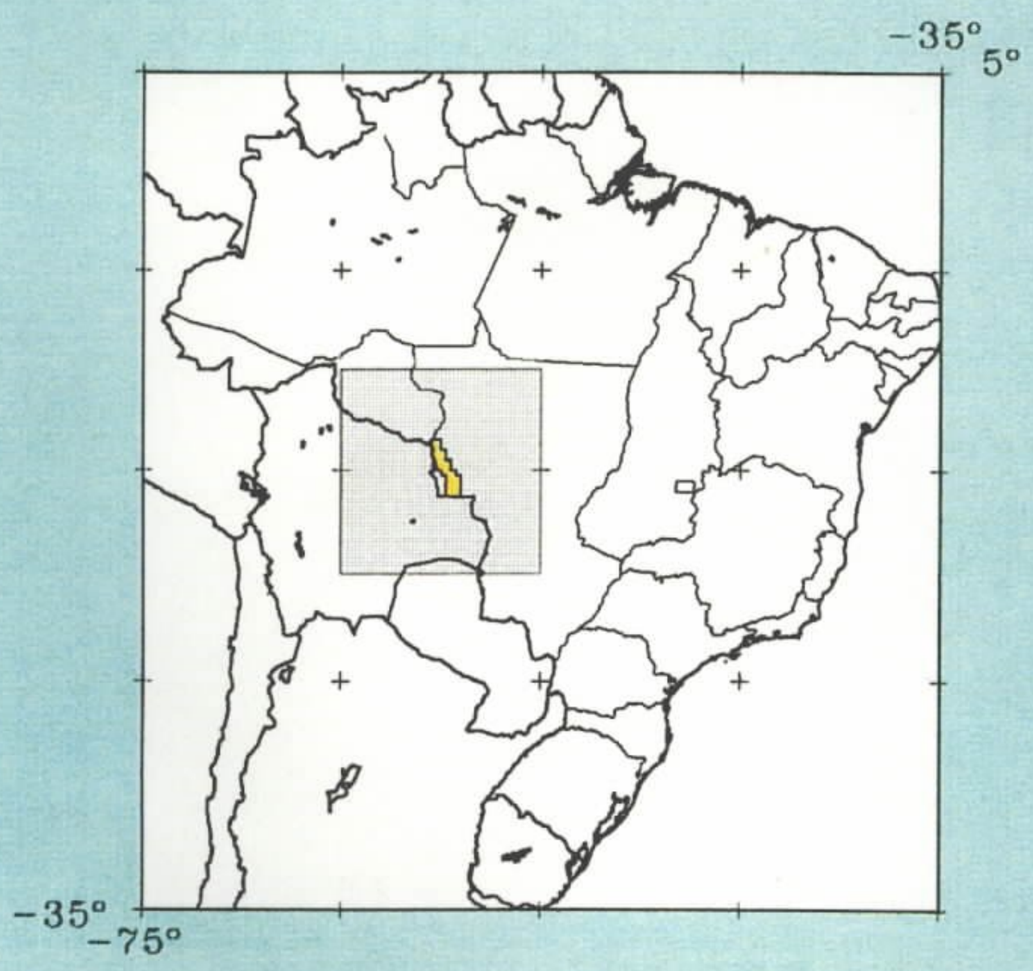
Thorium(Th) (MeV):	2.41 - 2.82	***Uranium(U) (MeV):***	1.66 - 1.86
Potassium(K) (MeV):	1.36 - 1.56	***Total Count(Tc) (MeV):***	0.78 - 2.82(1) 0.40 - 2.82(2)

Stripping Ratios

Alpha:	0.3320(1) 0.4272(2)	***Beta:***	0.7850(1) 0.8593(2)
Gamma:	0.2687(1) 0.3084(2)		

Comments: (1) Stabilized on cesium (2) Stabilized on cobalt.





Cabeceiras Do Rio Guapore

#1028

SAMMP #	**4050**	***CPRM #***	**1028**

Project	**Cabeceiras do Rio Guaporé**
Client:	**Departamento Nacional da Produção Mineral-DNPM**
Contractor:	**PROSPEC**
Survey Completion Year:	**1977**

Number of Sub-Areas:	2
Total Area (km²):	25 000
Line km:	24 178
Flight Direction:	N-S
Line Spacing (km):	1
Tie Line Spacing (km):	20
Flight Altitude (mtc) (m):	150
Gamma-Spectrometer:	Exploranium DIGRS-3001
Crystal Volume (in³):	830.94
Type of Aircraft:	Islander

Back-Calibrated Sensitivities

Thorium(Th) (cps/ppm): 2.04
Potassium(K) (cps/%): 34.52
Uranium(U) (cps/ppm): 17.0
Total Count(Tc) (cps/dose rate): 60.55

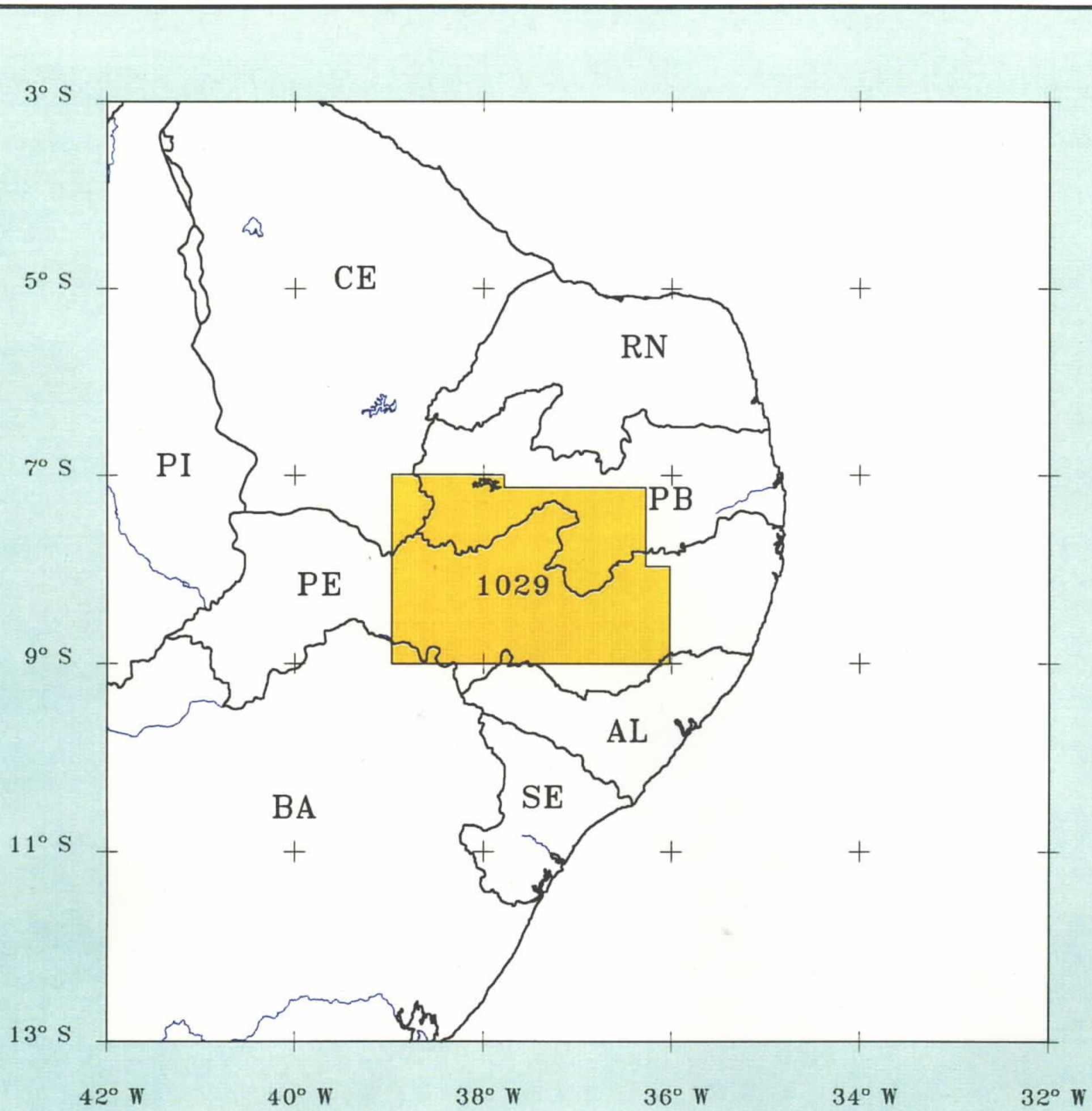
Window Sizes

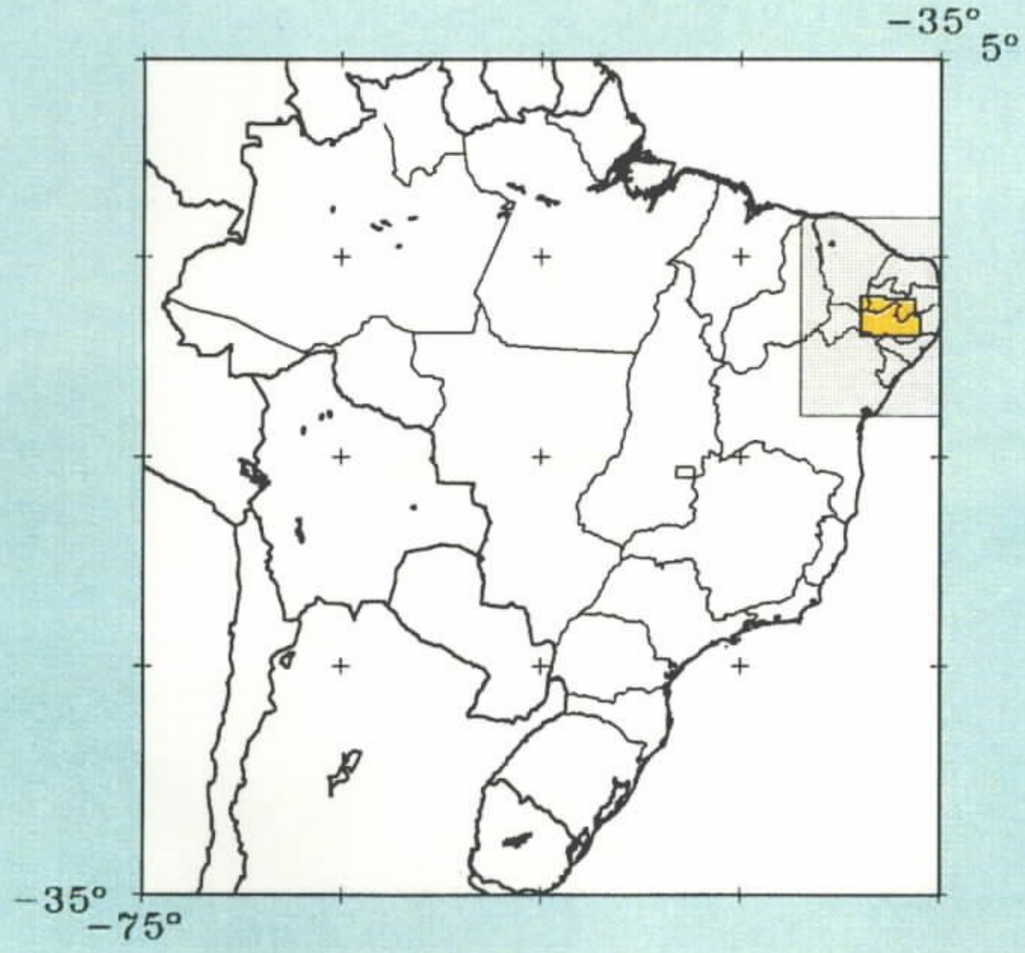
Thorium(Th) (MeV): 2.41 - 2.82
Potassium(K) (MeV): 1.36 - 1.56
Uranium(U) (MeV): 1.66 - 1.86
Total Count(Tc) (MeV): 0.78 - 2.82

Stripping Ratios

Alpha: 0.3080 0.3174 0.4359
Gamma: 0.2781 0.3994 0.3073
Beta: 0.8578 0.9277 0.8425

Comments: -





Cariris Velhos

#1029

SAMMP #	**4081**	***CPRM #***	**1029**

Project	**Cariris Velhos**
Client:	**Departamento Nacional da Produção Mineral-DNPM**
Contractor:	**GEOFOTO**
Survey Completion Year:	**1977**

Number of Sub-Areas:	1
Total Area (km²):	68 000
Line km:	37 500
Flight Direction:	N-S
Line Spacing (km):	2
Tie Line Spacing (km):	20
Flight Altitude (mtc) (m):	150
Gamma-Spectrometer:	Exploranium DIGRS-3001
Crystal Volume (in³):	1017.87
Type of Aircraft:	Islander

Back-Calibrated Sensitivities

Thorium(Th) (cps/ppm):	2.80
Potassium(K) (cps/%):	56.0
Uranium(U) (cps/ppm):	17.0
Total Count(Tc) (cps/dose rate):	94.0

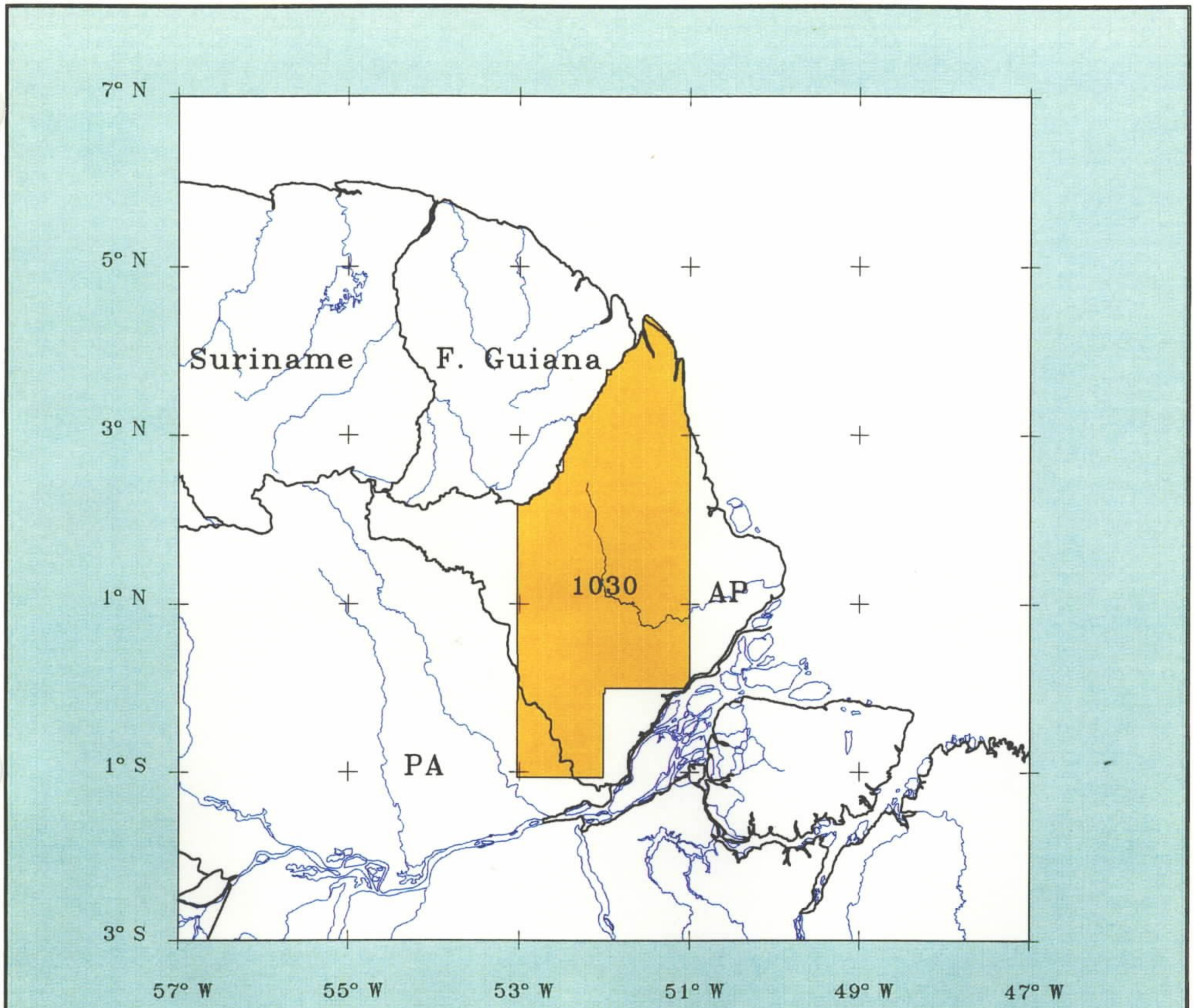
Window Sizes

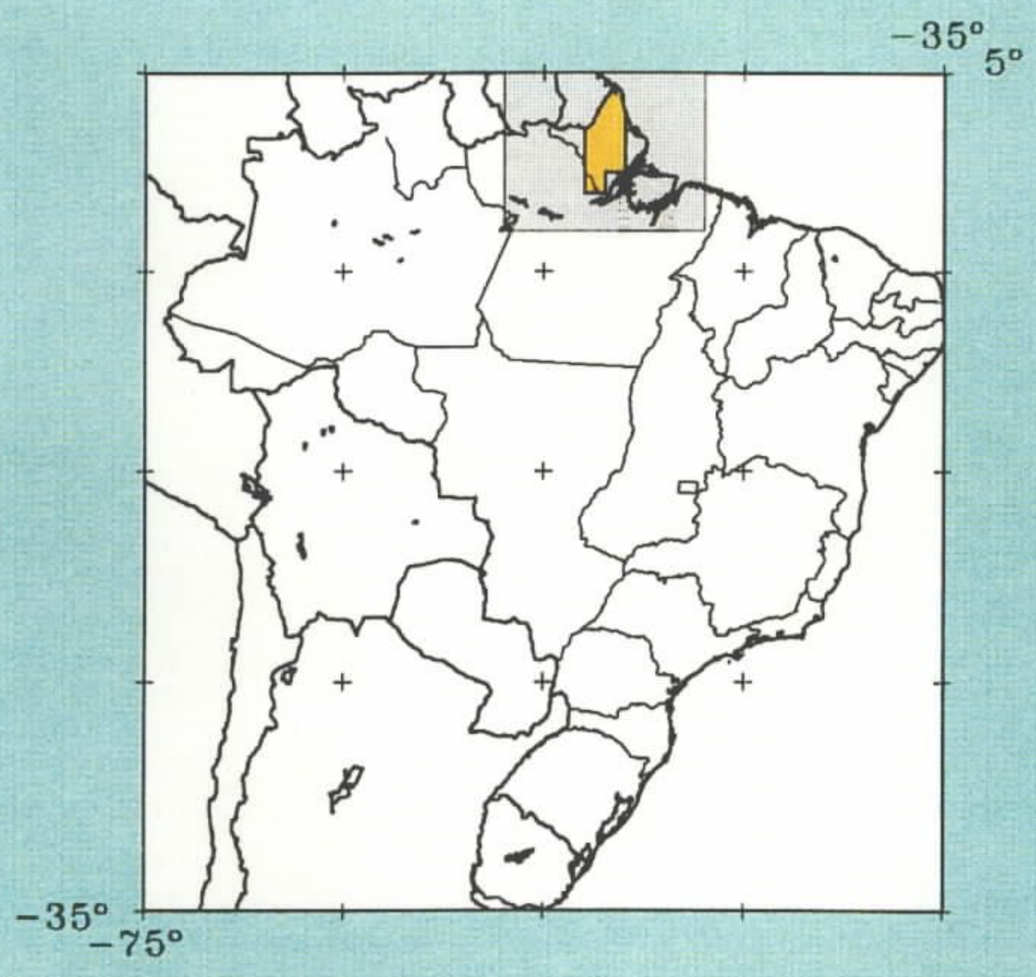
Thorium(Th) (MeV):	2.42 - 2.82	***Uranium(U) (MeV):***	1.66 - 1.86
Potassium(K) (MeV):	1.36 - 1.56	***Total Count(Tc) (MeV):***	0.9 - 2.82

Stripping Ratios

Alpha:	0.36	***Beta:***	0.47
Gamma:	0.73		

Comments: -





Jari–Rio Negro Leste I

#1030

SAMMP #	**4046**	***CPRM #***	**1030**

Project	**Jari-Rio Negro Leste I**
Client:	**Departamento Nacional da Produção Mineral-DNPM**
Contractor:	**PROSPEC**
Survey Completion Year:	**1977**

Number of Sub-Areas:	2
Total Area (km²):	94 000
Line km:	52 612
Flight Direction:	N-S
Line Spacing (km):	2
Tie Line Spacing (km):	20
Flight Altitude (mtc) (m):	150
Gamma-Spectrometer:	Exploranium DIGRS-3001
Crystal Volume (in³):	830.94
Type of Aircraft:	Islander

Back-Calibrated Sensitivities

Thorium(Th) (cps/ppm): 2.04
Potassium(K) (cps/%): 27.0
Uranium(U) (cps/ppm): 5.26
Total Count(Tc) (cps/dose rate): 60.55

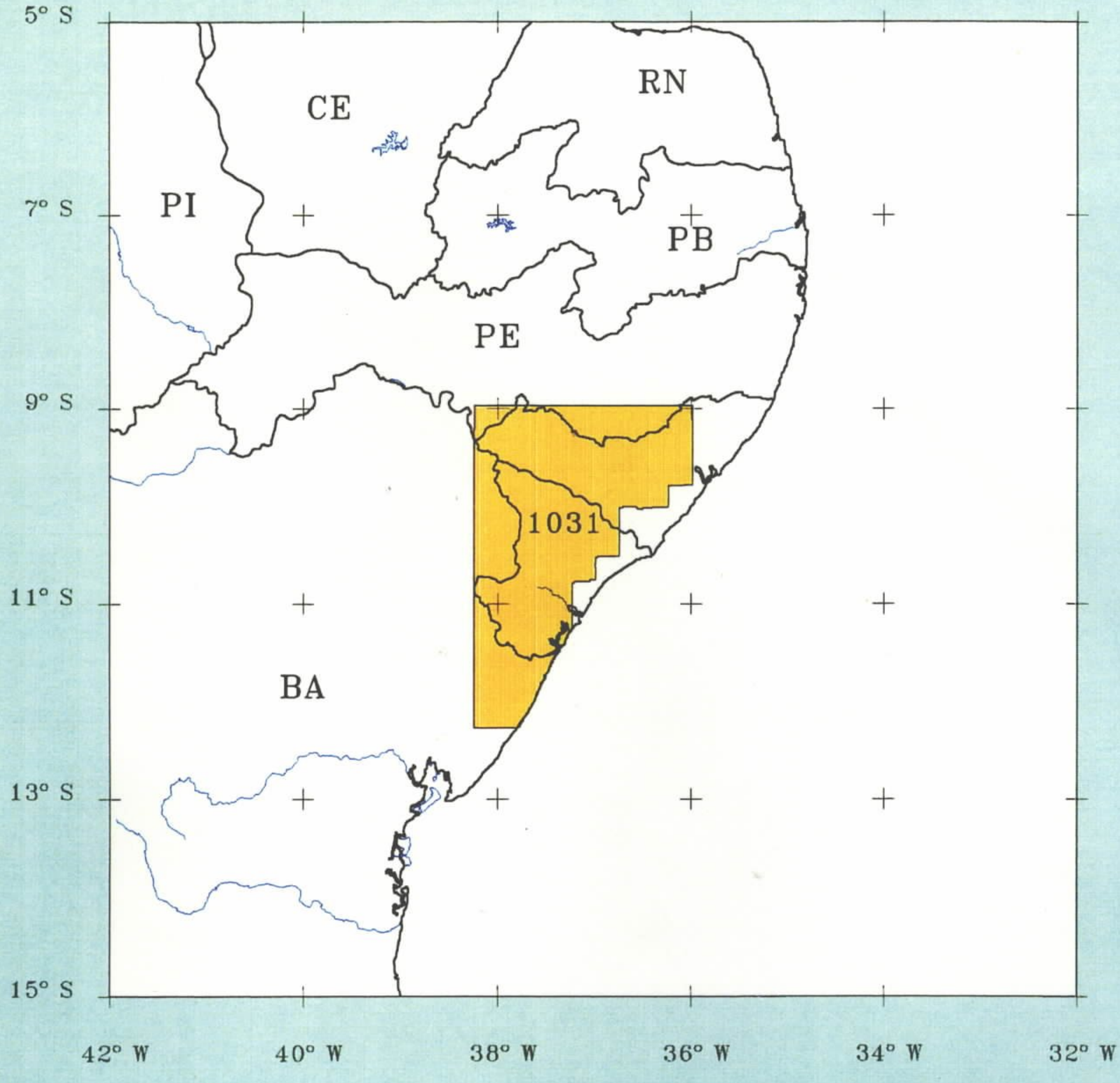
Window Sizes

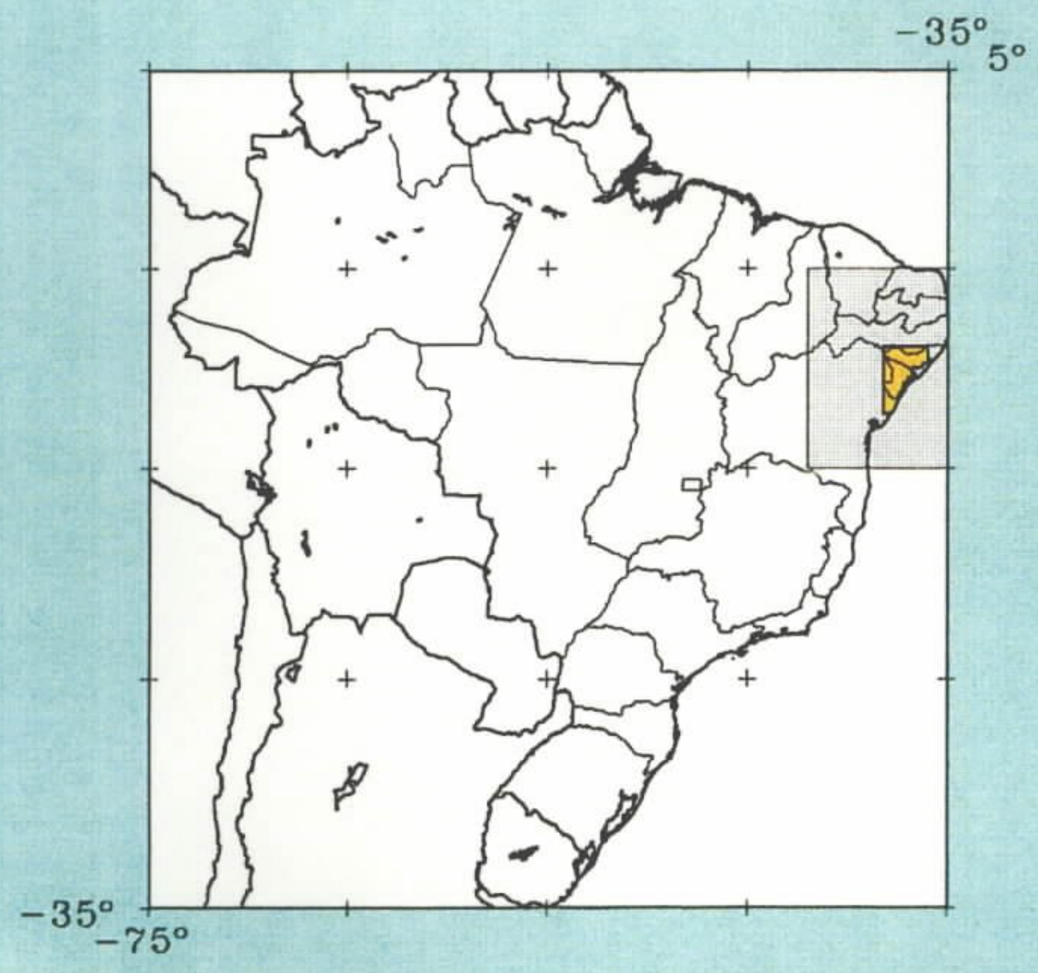
Thorium(Th) (MeV): 2.41 - 2.82
Potassium(K) (MeV): 1.36 - 1.56
Uranium(U) (MeV): 1.66 - 1.86
Total Count(Tc) (MeV): 0.78 - 2.82

Stripping Ratios

Alpha:	0.411	0.295	0.304	0.314	0.302	***Beta:***	0.764	0.945	0.848	0.852	0.716
Gamma:	0.453	0.382	0.354	0.255	0.228						

Comments: -





Baixo Sao Francisco

#1031

SAMMP # **4082** *CPRM #* **1031**

Project	**Baixo São Francisco**
Client:	**Departamento Nacional da Produção Mineral-DNPM**
Contractor:	**ENCAL**
Survey Completion Year:	**1978**

Number of Sub-Areas:	3
Total Area (km^2):	55 000
Line km:	30 593
Flight Direction:	N-S
Line Spacing (km):	2
Tie Line Spacing (km):	20
Flight Altitude (mtc) (m):	150
Gamma-Spectrometer:	Exploranium DIGRS-3001
Crystal Volume (in^3):	1017.87
Type of Aircraft:	Islander

Back-Calibrated Sensitivities

Thorium(Th) (cps/ppm): 1.60
Potassium(K) (cps/%): 39.0
Uranium(U) (cps/ppm): 6.5
Total Count(Tc) (cps/dose rate): 51.79

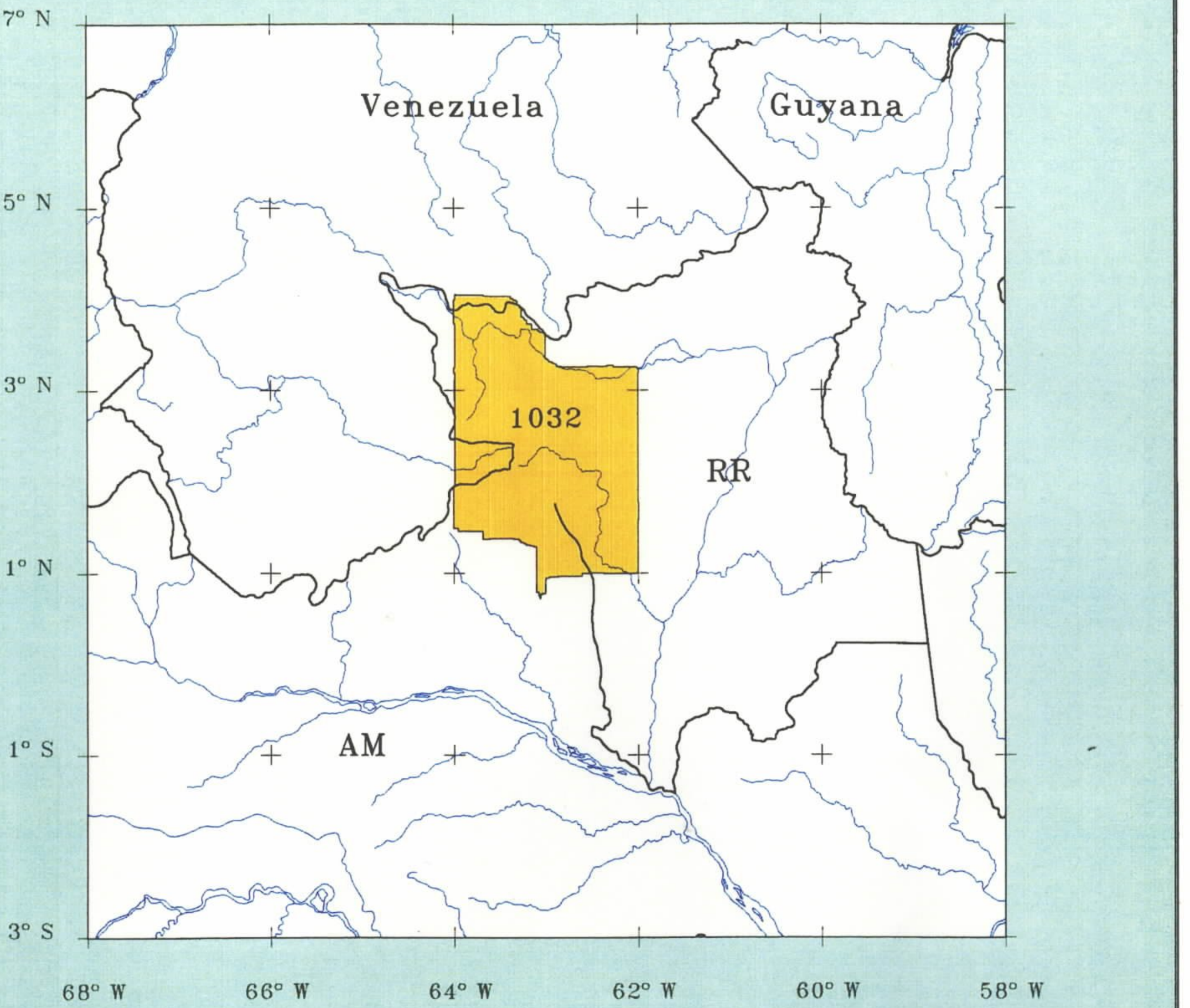
Window Sizes

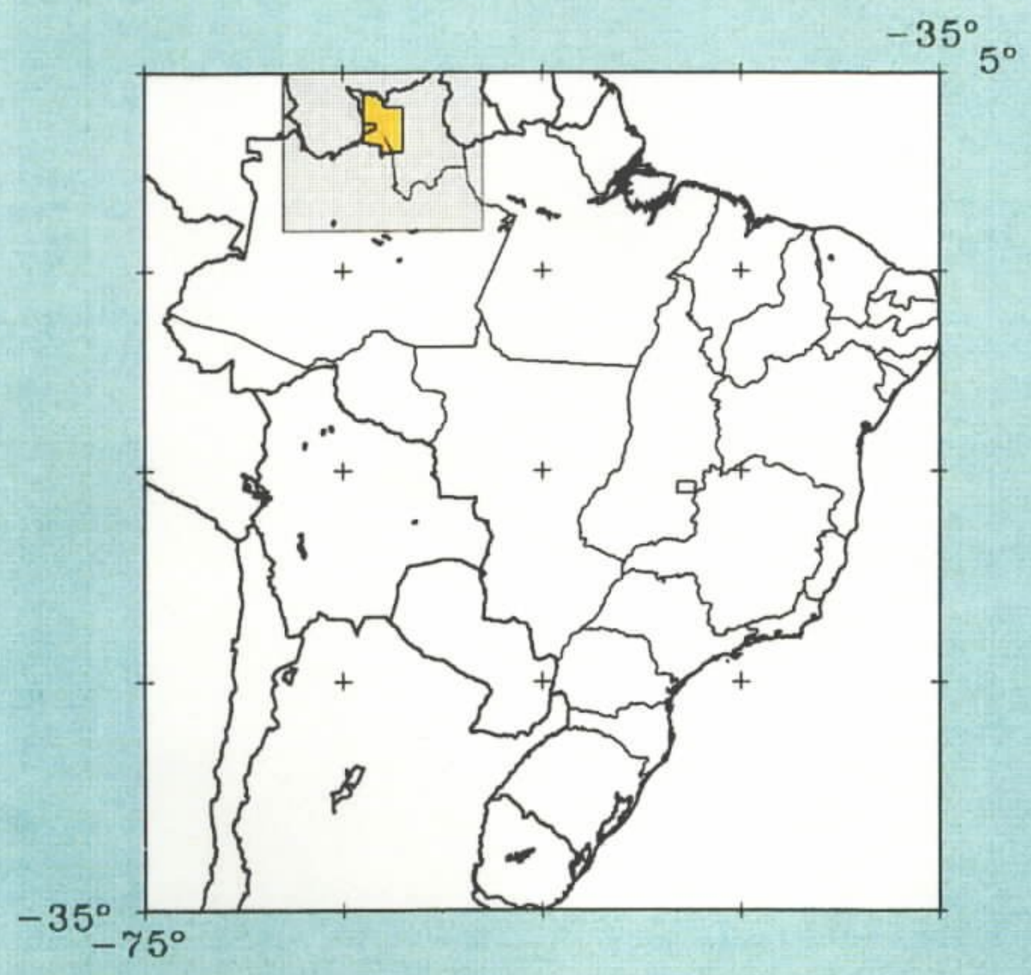
Thorium(Th) (MeV): 2.42 - 2.82
Potassium(K) (MeV): 1.36 - 1.56
Uranium(U) (MeV): 1.66 - 1.86
Total Count(Tc) (MeV): 0.4 - 2.82

Stripping Ratios

Alpha:
Beta:
Gamma:

Comments: -





Uraricoera

#1032

SAMMP # **4054** *CPRM #* **1032**

Project	**Uraricoera**
Client:	**Departamento Nacional da Produção Mineral-DNPM**
Contractor:	**PROSPEC**
Survey Completion Year:	**1977**

Number of Sub-Areas:	2
Total Area (km²):	49 500
Line km:	31 138
Flight Direction:	N-S
Line Spacing (km):	2
Tie Line Spacing (km):	20
Flight Altitude (mtc) (m):	150
Gamma-Spectrometer:	Exploranium DIGRS-3001
Crystal Volume (in³):	830.94
Type of Aircraft:	Islander

Back-Calibrated Sensitivities

Thorium(Th) (cps/ppm):	2.04
Potassium(K) (cps/%):	20.0
Uranium(U) (cps/ppm):	5.26
Total Count(Tc) (cps/dose rate):	60.55

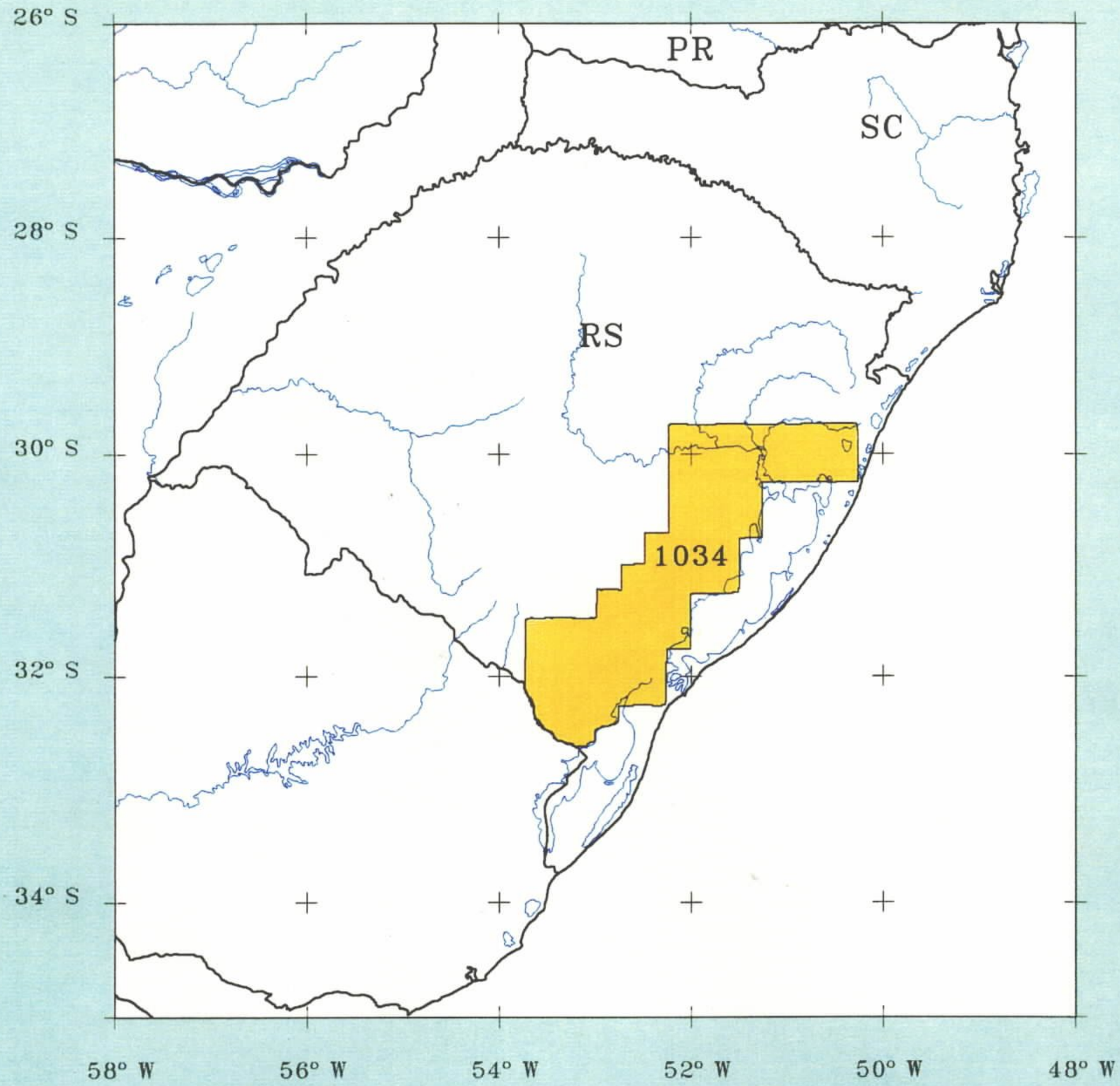
Window Sizes

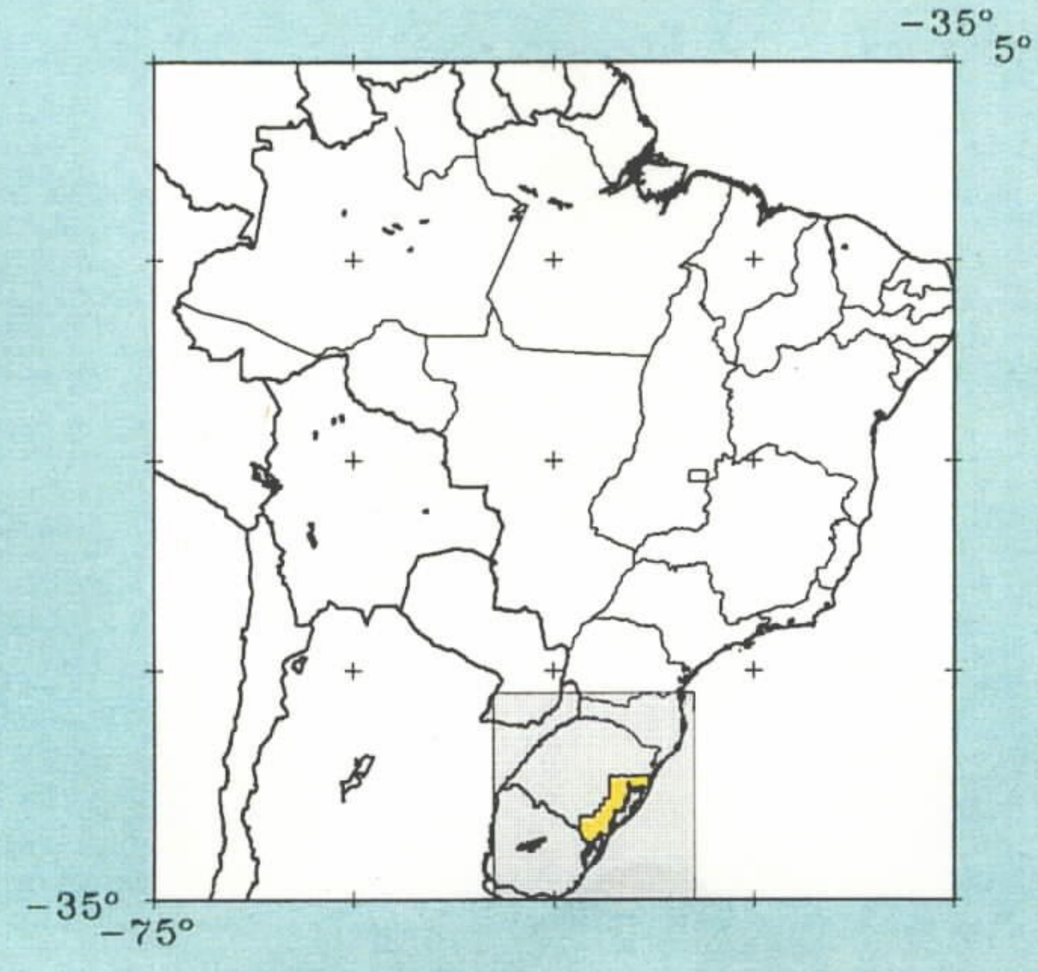
Thorium(Th) (MeV):	2.41 - 2.82	*Uranium(U) (MeV):*	1.66 - 1.86
Potassium(K) (MeV):	1.36 - 1.56	*Total Count(Tc) (MeV):*	0.78 - 2.82

Stripping Ratios

Alpha:	0.2826 0.2929	*Beta:*	0.8253 0.8016
Gamma:	0.3900 0.2819		

Comments: -





Extremo-Sudeste Do Brasil

#1034

SAMMP #	**4030**	***CPRM #***	**1034**

Project	**Extremo-Sudeste do Brasil**
Client:	**Departamento Nacional da Produção Mineral-DNPM**
Contractor:	**LASA**
Survey Completion Year:	**1978**

Number of Sub-Areas:	2
Total Area (km²):	41 000
Line km:	44 023
Flight Direction:	N-S
Line Spacing (km):	1
Tie Line Spacing (km):	10
Flight Altitude (mtc) (m):	150
Gamma-Spectrometer:	Exploranium DIGRS-3001
Crystal Volume (in³):	1017.87
Type of Aircraft:	DC-3 (East) Islander (West)

Back-Calibrated Sensitivities

Thorium(Th) (cps/ppm):	1.50(1)	1.50(2)
Potassium(K) (cps/%):	25.88(1)	18.5(2)
Uranium(U) (cps/ppm):	4.7(1)	7.1(2)
Total Count(Tc) (cps/dose rate):	43.0(1)	43.0(2)

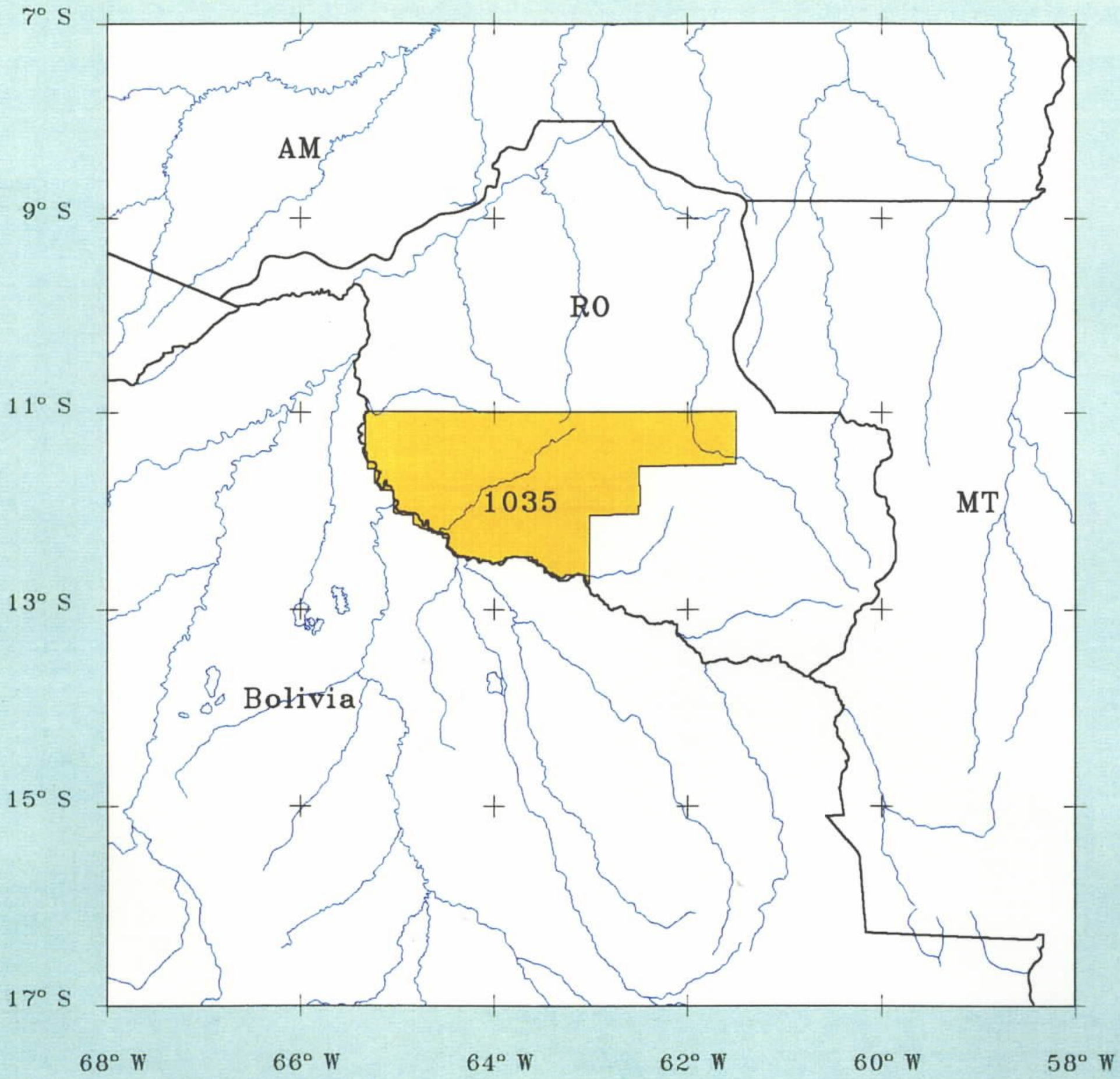
Window Sizes

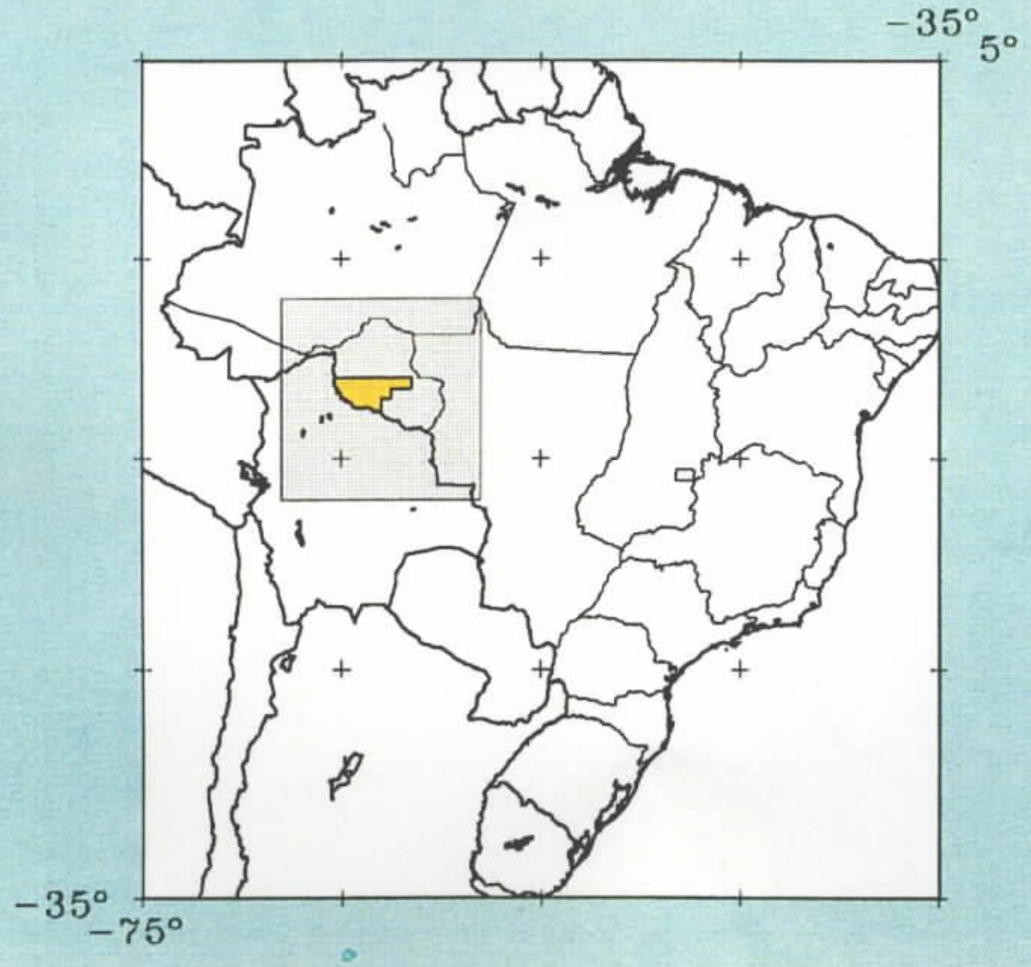
Thorium(Th) (MeV):	2.42 - 2.82	***Uranium(U) (MeV):***	1.68 - 1.88
Potassium(K) (MeV):	1.36 - 1.56	***Total Count(Tc) (MeV):***	0.9 - 2.82

Stripping Ratios

Alpha:	0.359	***Beta:***	0.478
Gamma:	0.75		

Comments: Two types of aircraft used: DC-3 (East of 52° 15' W) and Islander (West of 52° 15' W).





Pacaas Novos

#1035

SAMMP #	**4048**	***CPRM #***	**1035**

Project	**Pacaás Novos**
Client:	**Departamento Nacional da Produção Mineral-DNPM**
Contractor:	**GEOFOTO**
Survey Completion Year:	**1978**

Number of Sub-Areas:	1
Total Area (km²):	49 000
Line km:	28 003
Flight Direction:	N-S
Line Spacing (km):	2
Tie Line Spacing (km):	20
Flight Altitude (mtc) (m):	150
Gamma-Spectrometer:	Exploranium DIGRS-3001
Crystal Volume (in³):	1017.87
Type of	Islander

Back-Calibrated Sensitivities

Thorium(Th) (cps/ppm): 1.40
Potassium(K) (cps/%): 25.88
Uranium(U) (cps/ppm): 9.2
Total Count(Tc) (cps/dose rate): 51.79

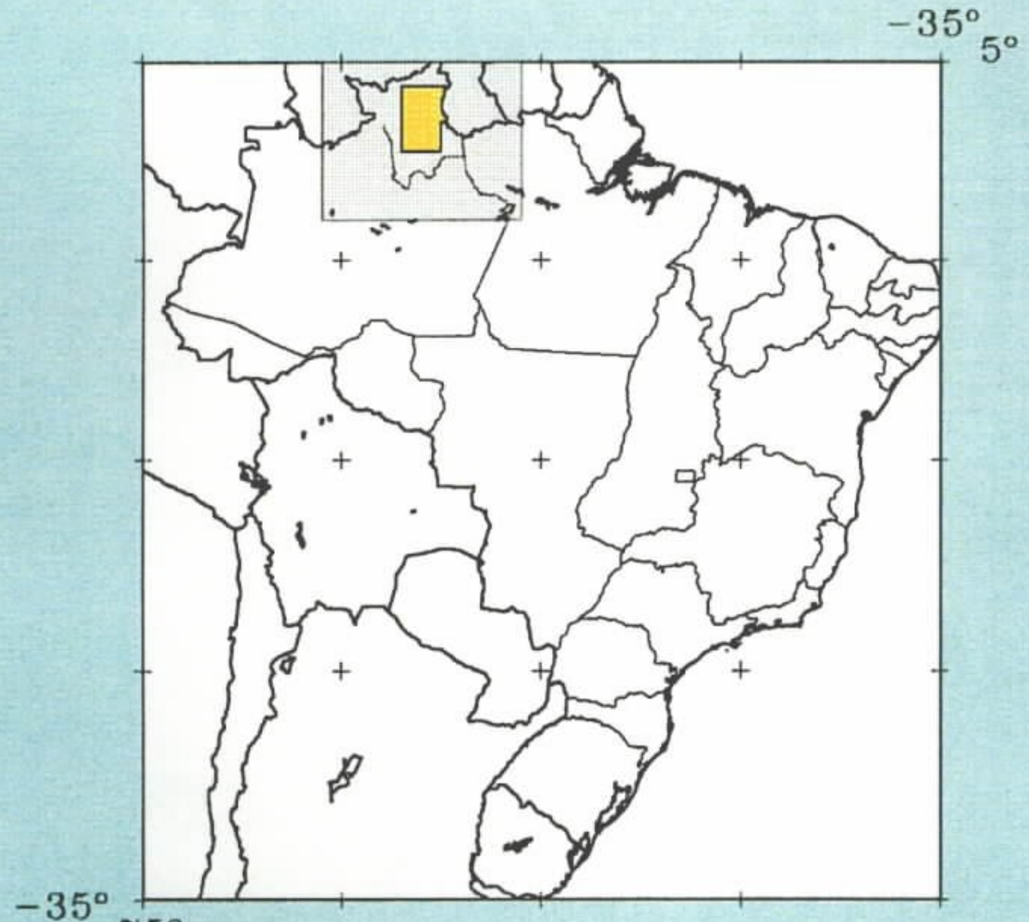
Window Sizes

Thorium(Th) (MeV): 2.42 - 2.82
Potassium(K) (MeV): 1.36 - 1.56
Uranium(U) (MeV): 1.68 - 1.88
Total Count(Tc) (MeV): 0.9 - 2.82

Stripping Ratios

Alpha: 0.341
Beta: 0.479
Gamma: 0.749

Comments: -



Rio Branco

#1036

SAMMP # **4084** *CPRM #* **1036**

Project	**Rio Branco**
Client:	**Departamento Nacional da Produção Mineral-DNPM**
Contractor:	**PROSPEC**
Survey Completion Year:	**1978**

Number of Sub-Areas:	4
Total Area (km²):	82 000
Line km:	45 800
Flight Direction:	N-S
Line Spacing (km):	2
Tie Line Spacing (km):	20
Flight Altitude (mtc) (m):	150
Gamma-Spectrometer:	Exploranium DIGRS-3001
Crystal Volume (in³):	830.94
Type of Aircraft:	Islander

Back-Calibrated Sensitivities

Thorium(Th) (cps/ppm): 0.8
Potassium(K) (cps/%): 9.0
Uranium(U) (cps/ppm): 2.0
Total Count(Tc) (cps/dose rate): 20.0

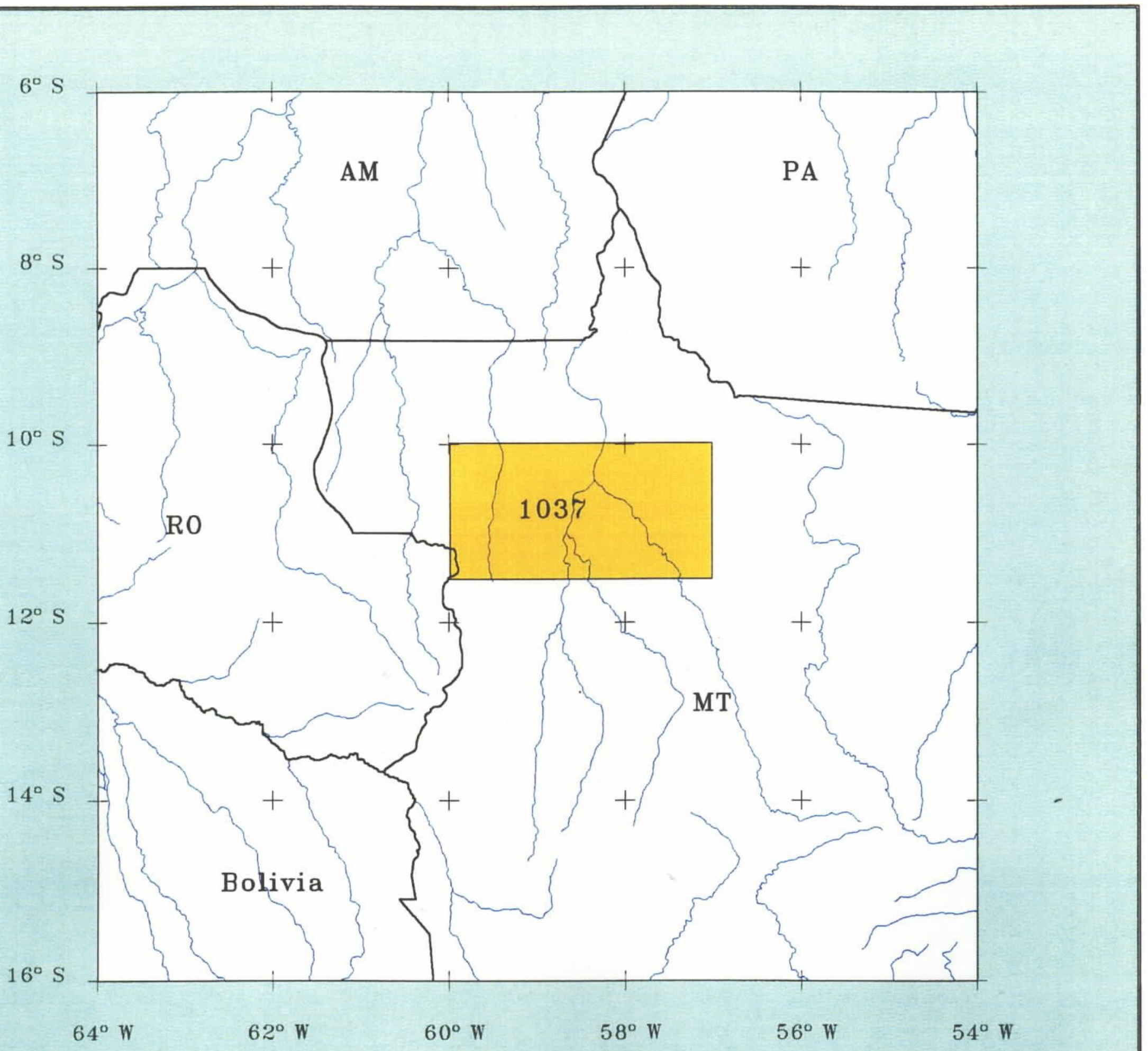
Window Sizes

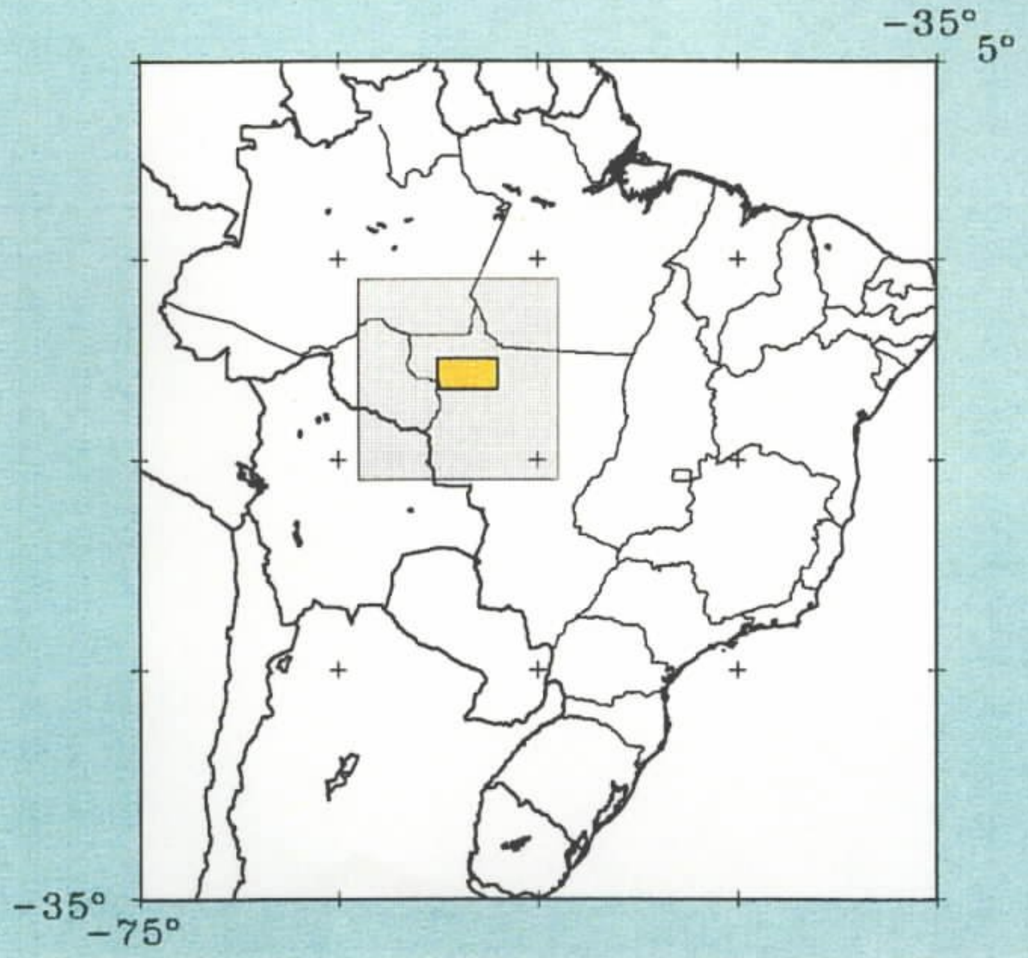
Thorium(Th) (MeV): 2.41 - 2.82
Potassium(K) (MeV): 1.36 - 1.56
Uranium(U) (MeV): 1.66 - 1.86
Total Count(Tc) (MeV): 0.78 - 2.82

Stripping Ratios

Alpha: 0.367
Beta: 0.507
Gamma: 0.781

Comments: -





Rio Do Sangue

#1037

SAMMP #	**4051**	***CPRM #***	**1037**

Project	**Rio do Sangue**
Client:	**Departamento Nacional da Produção Mineral-DNPM**
Contractor:	**GEOFOTO S.A.**
Survey Completion Year:	**1978**

Number of Sub-Areas:	1
Total Area (km^2):	54 000
Line km:	30 360
Flight Direction:	N-S
Line Spacing (km):	2
Tie Line Spacing (km):	20
Flight Altitude (mtc) (m):	150
Gamma-Spectrometer:	Exploranium DIGRS-3001
Crystal Volume (in^3):	1017.87
Type of Aircraft:	Islander

Back-Calibrated Sensitivities

Thorium(Th) (cps/ppm):	1.78
Potassium(K) (cps/%):	25.88
Uranium(U) (cps/ppm):	10.07
Total Count(Tc) (cps/dose rate):	51.79

Window Sizes

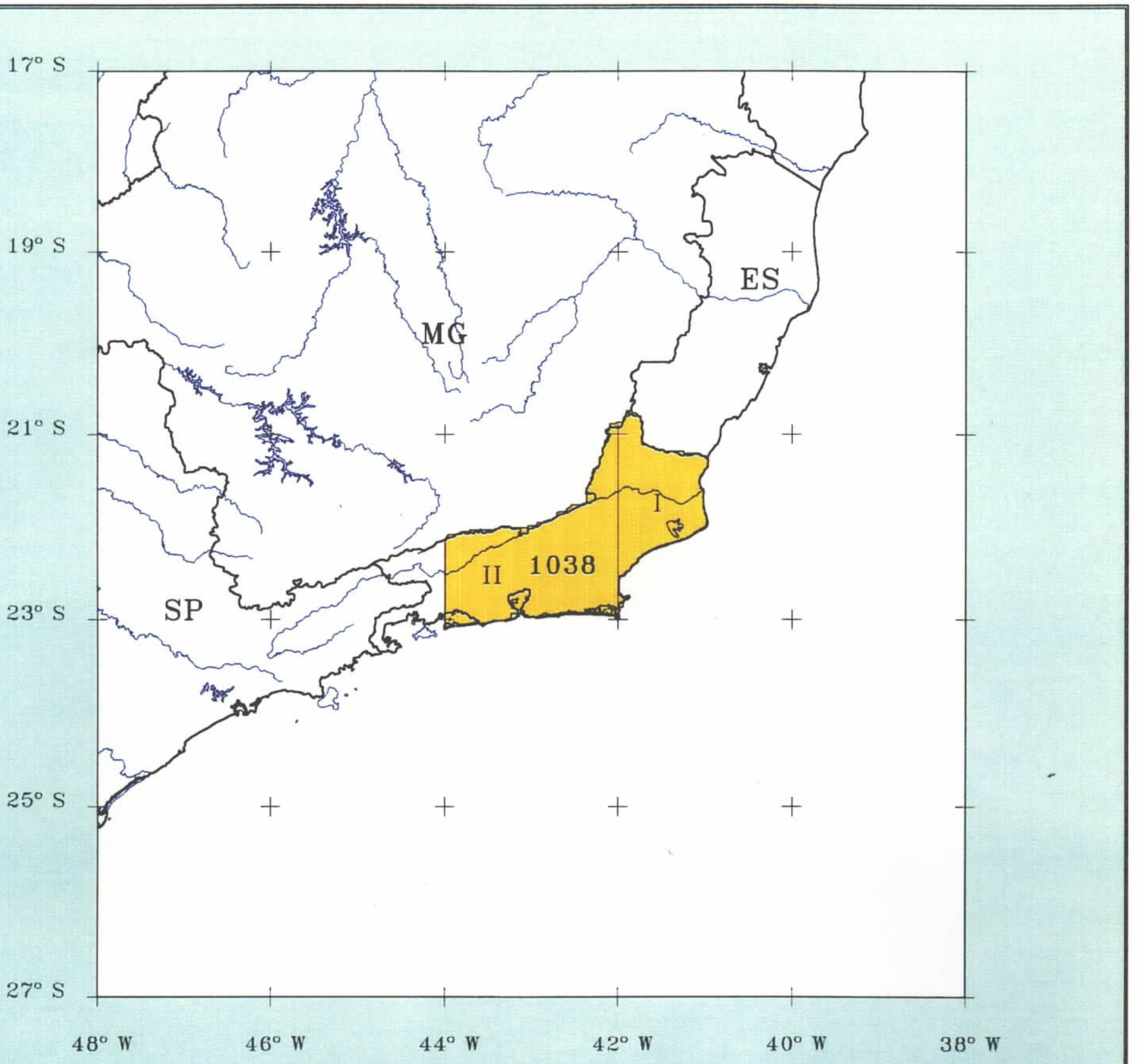
Thorium(Th) (MeV):	2.42 - 2.82	***Uranium(U) (MeV):***	1.68 - 1.88
Potassium(K) (MeV):	1.36 - 1.56	***Total Count(Tc) (MeV):***	0.9 - 2.82

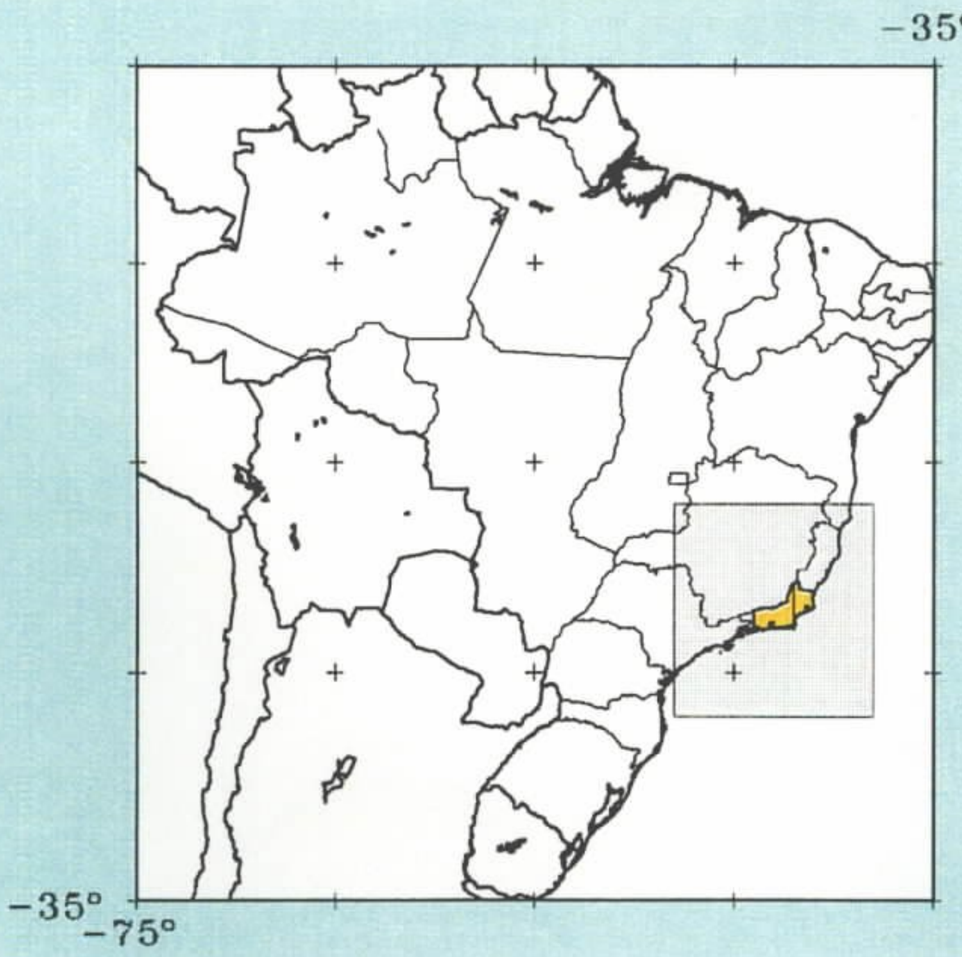
Stripping Ratios

Alpha:	0.359	***Beta:***	0.478
Gamma:	0.75		

Comments: -

60





Sao Paulo–Rio De Janeiro
(Area Rio De Janeiro)

#1038

SAMMP #	**4085.01**	*CPRM #*	**1038.01**

Project	**São Paulo-Rio de Janeiro (Area RJ)**
Client:	**Departamento Nacional da Produção Mineral-DNPM**
Contractor:	**ENCAL S.A.**
Survey Completion Year:	**1978**

Number of Sub-Areas:	1
Total Area (km²):	16 000
Line km:	15 100
Flight Direction:	N-S
Line Spacing (km):	1
Tie Line Spacing (km):	10
Flight Altitude (mtc) (m):	150
Gamma-Spectrometer:	Exploranium DIGRS-3001
Crystal Volume (in³):	1024
Type of Aircraft:	Islander

Back-Calibrated Sensitivities

Thorium(Th) (cps/ppm): 1.33
Potassium(K) (cps/%): 21.92
Uranium(U) (cps/ppm): 4.8
Total Count(Tc) (cps/dose rate): 41.55

Window Sizes

Thorium(Th) (MeV): 2.42 - 2.82
Uranium(U) (MeV): 1.66 - 1.86
Potassium(K) (MeV): 1.36 - 1.56
Total Count(Tc) (MeV): 0.66 - 2.82

Stripping Ratios

Alpha: 0.359
Beta: 0.478
Gamma: 0.749

Comments: -

SAMMP #	**4085.02**	*CPRM #*	**1038.02**

Project	**São Paulo-Rio de Janeiro (Area RJ)**
Client :	**Departamento Nacional da Produção Mineral-DNPM**
Contractor:	**ENCAL S.A.**
Survey Completion Year:	**1978**

Number of Sub-Areas:	1
Total Area (km^2):	32 000
Line km:	30 000
Flight Direction:	N-S
Line Spacing (km):	1
Tie Line Spacing (km):	10
Flight Altitude (mtc) (m):	150
Gamma-Spectrometer:	Geometrics GR-800A
Crystal Volume (in^3):	3072
Type of Aircraft:	Bandeirante

Back-Calibrated Sensitivities

Thorium(Th) (cps/ppm): 5.56
Potassium(K) (cps/%): 75.23
Uranium(U) (cps/ppm): 8.42
Total Count(Tc) (cps/dose rate): 207.16

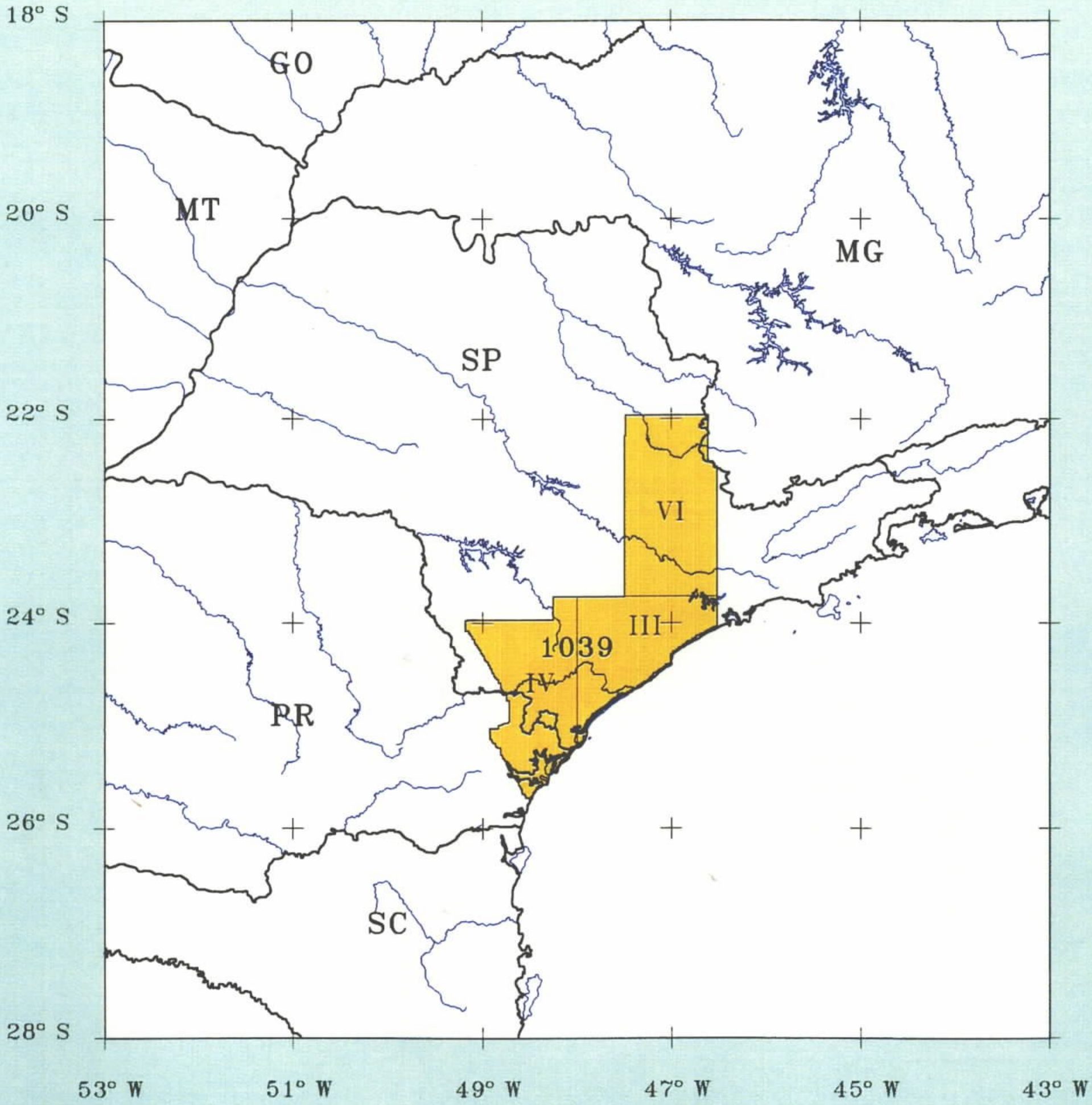
Window Sizes

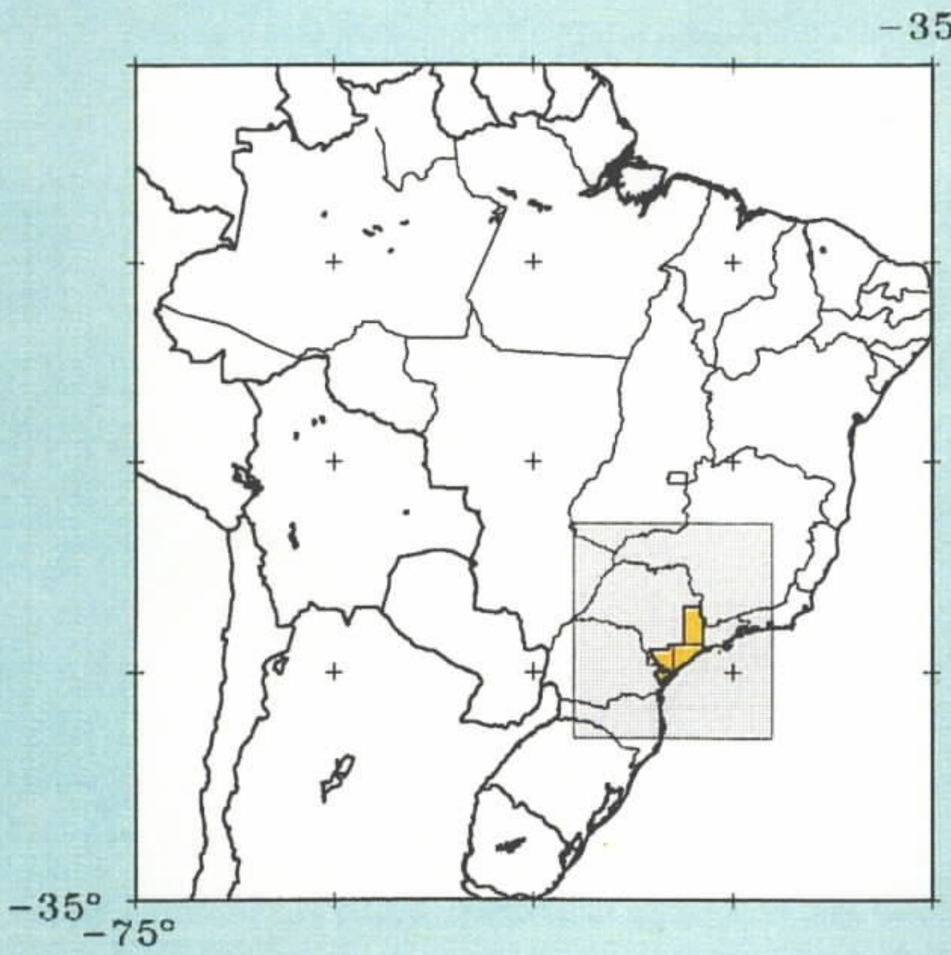
Thorium(Th) (MeV): 2.42 - 2.82
Potassium(K) (MeV): 1.36 - 1.56
Uranium(U) (MeV): 1.66 - 1.86
Total Count(Tc) (MeV): 0.66 - 2.82

Stripping Ratios

Alpha: 0.346
Beta: 0.328
Gamma: 0.549

Comments: -





Sao Paulo-Rio De Janeiro
(Area Sao Paulo)

#1039

SAMMP #	**4086.03**	*CPRM #*	**1039.03**

Project	**São Paulo-Rio de Janeiro (Area SP)**
Client:	**Departamento Nacional da Produção Mineral-DNPM**
Contractor :	**ENCAL**
Survey Completion Year:	**1979**

Number of Sub-Areas:	1
Total Area (km²):	17 000
Line km:	15 000
Flight Direction:	N-S
Line Spacing (km):	1
Tie Line Spacing (km):	10
Flight Altitude (mtc) (m):	150
Gamma-Spectrometer:	Exploranium DIGRS-3001
Crystal Volume (in³):	1024
Type of Aircraft:	Islander

Back-Calibrated Sensitivities

Thorium(Th)	1.33
Potassium(K)	14.0
Uranium(U)	3.8
Total Count(Tc) (cps/dose	41.55

Window Sizes

Thorium(Th)	2.42 - 2.82	*Uranium(U)*	1.66 - 1.86
Potassium(K)	1.36 - 1.56	*Total Count(Tc)*	0.66 - 2.82

Stripping Ratios

Alpha:	0.359	*Beta:*	0.478
Gamma:	0.749		

Comments: -

SAMMP #	**4086.04**	***CPRM #***	**1039.04**

Project	**São Paulo-Rio de Janeiro (Area SP)**
Client :	**Departamento Nacional da Produção Mineral-DNPM**
Contractor :	**ENCAL**
Survey Completion Year:	1979

Number of Sub-Areas:	1
Total Area (km²):	20 000
Line km:	18 000
Flight Direction:	N-S
Line Spacing (km):	1
Tie Line Spacing (km):	10
Flight Altitude (mtc) (m):	150
Gamma-Spectrometer:	Geometrics GR-800A
Crystal Volume (in³):	3072
Type of Aircraft:	Bandeirante

Back-Calibrated Sensitivities

Thorium(Th) (cps/ppm): 5.56
Potassium(K) (cps/%): 75.23
Uranium(U) (cps/ppm): 8.42
Total Count(Tc) (cps/dose rate): 207.16

Window Sizes

Thorium(Th) (MeV): 2.42 - 2.82
Uranium(U) (MeV): 1.66 - 1.86
Potassium(K) (MeV): 1.36 - 1.56
Total Count(Tc) (MeV): 0.66 - 2.82

Stripping Ratios

Alpha: 0.346
Beta: 0.328
Gamma: 0.549

Comments: -

SAMMP #	**4086.06**	*CPRM #*	**1039.06**

Project	**São Paulo-Rio de Janeiro (Area SP)**
Client:	**Departamento Nacional da Produção Mineral-DNPM**
Contractor:	**ENCAL**
Survey Completion Year:	***1979***

Number of Sub-Areas:	1
Total Area (km²):	23 000
Line km:	21 000
Flight Direction:	N-S
Line Spacing (km):	1
Tie Line Spacing (km):	10
Flight Altitude (mtc) (m):	150
Gamma-Spectrometer:	Geometrics GR-800A
Crystal Volume (in³):	3072
Type of Aircraft:	Bandeirante

Back-Calibrated Sensitivities

Thorium(Th) (cps/ppm): 4.00
Potassium(K) (cps/%): 75.23
Uranium(U) (cps/ppm): 5.7
Total Count(Tc) (cps/dose rate): 207.16

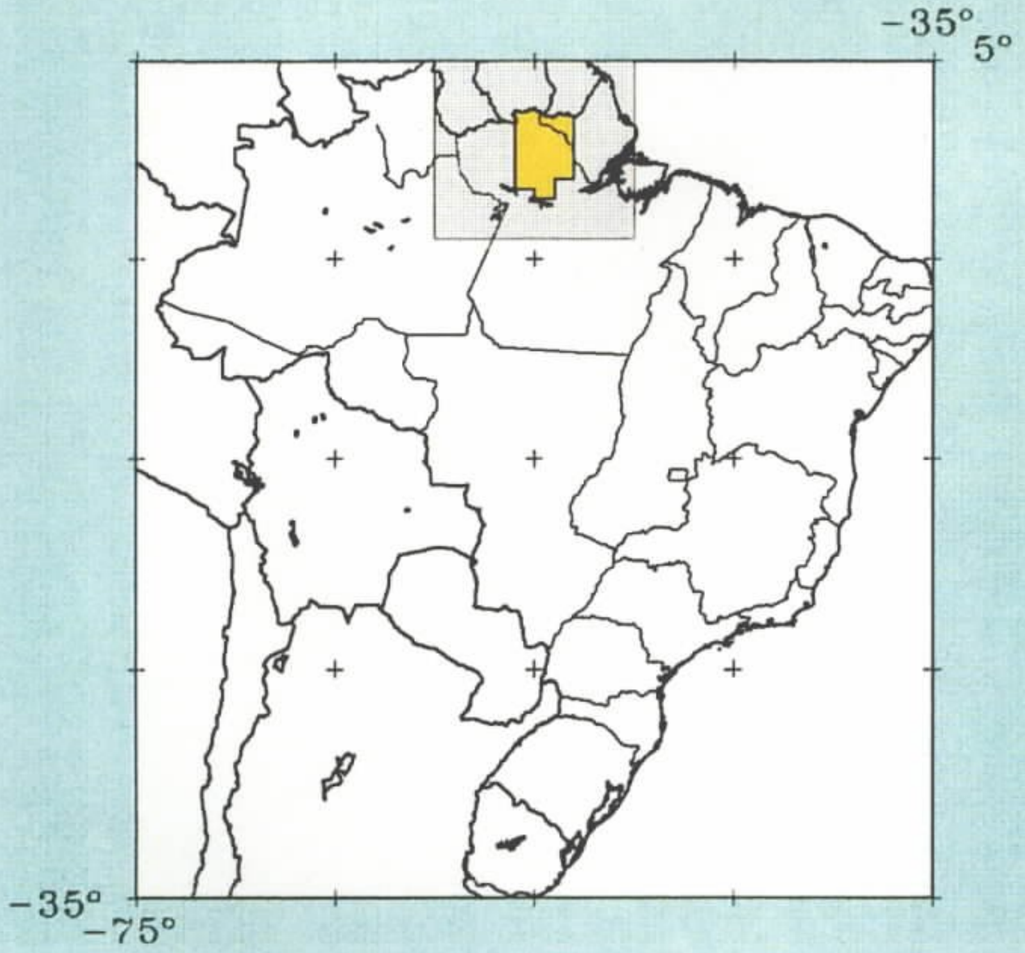
Window Sizes

Thorium(Th) (MeV): 2.42 - 2.82
Uranium(U) (MeV): 1.66 - 1.86
Potassium(K) (MeV): 1.36 - 1.56
Total Count(Tc) (MeV): 0.66 - 2.82

Stripping Ratios

Alpha: 0.346
Beta: 0.328
Gamma: 0.549

Comments: -



Jari–Rio Negro Leste II

#1041

SAMMP #	**4045**	***CPRM #***	**1041**

Project	**Jari-Rio Negro Leste II**
Client:	**Departamento Nacional da Produção Mineral-DNPM**
Contractor:	**PROSPEC**
Survey Completion Year:	**1978**

Number of Sub-Areas:	4
Total Area (km²):	141 750
Line km:	78 517
Flight Direction:	N-S
Line Spacing (km):	2
Tie Line Spacing (km):	20
Flight Altitude (mtc) (m):	150
Gamma-Spectrometer:	Exploranium DIGRS-3001
Crystal Volume (in³):	830.94
Type of Aircraft:	Islander

Back-Calibrated Sensitivities

Thorium(Th) (cps/ppm): 0.95
Potassium(K) (cps/%): 34.52
Uranium(U) (cps/ppm): 1.9
Total Count(Tc) (cps/dose rate): 25.7

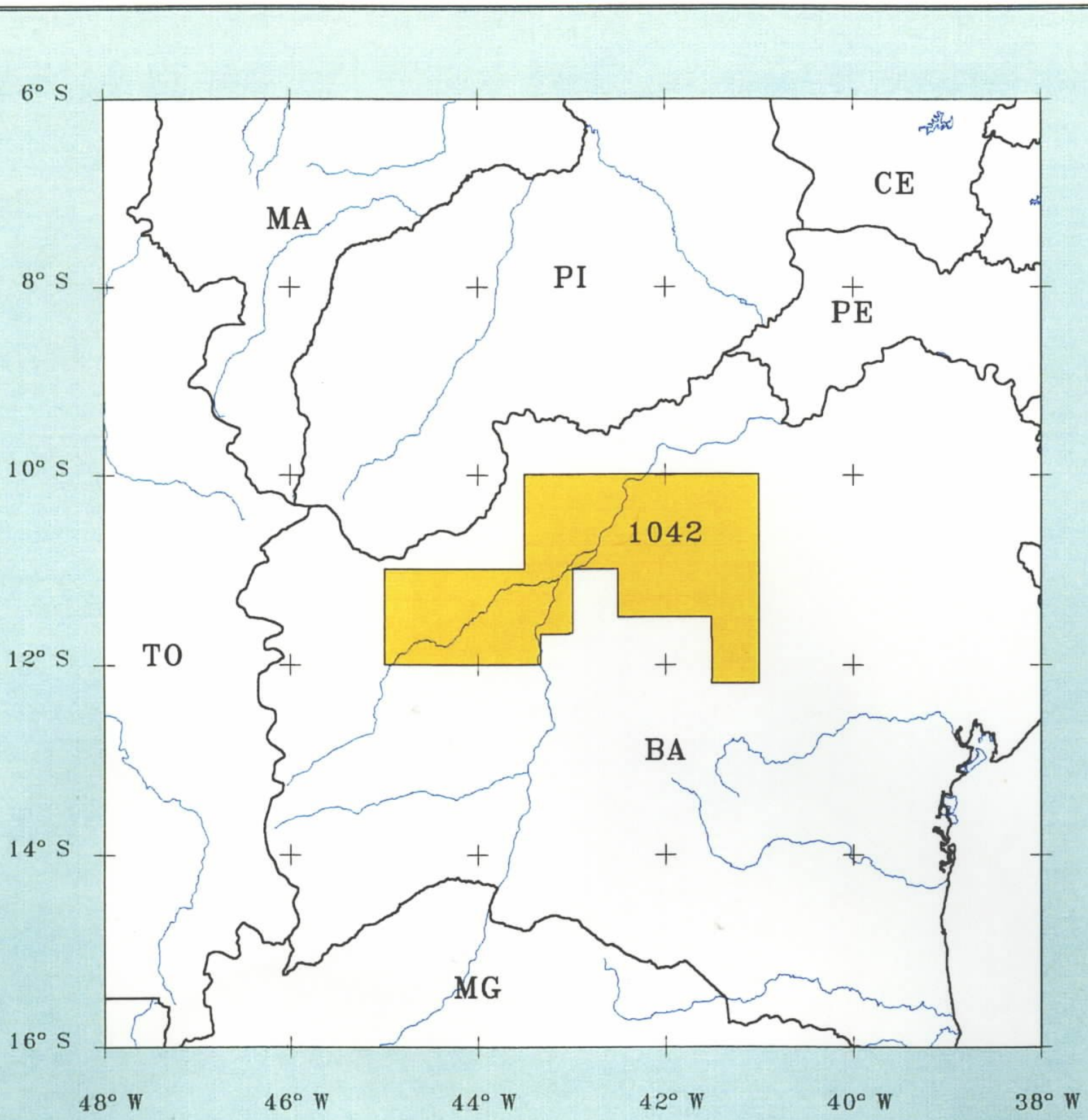
Window Sizes

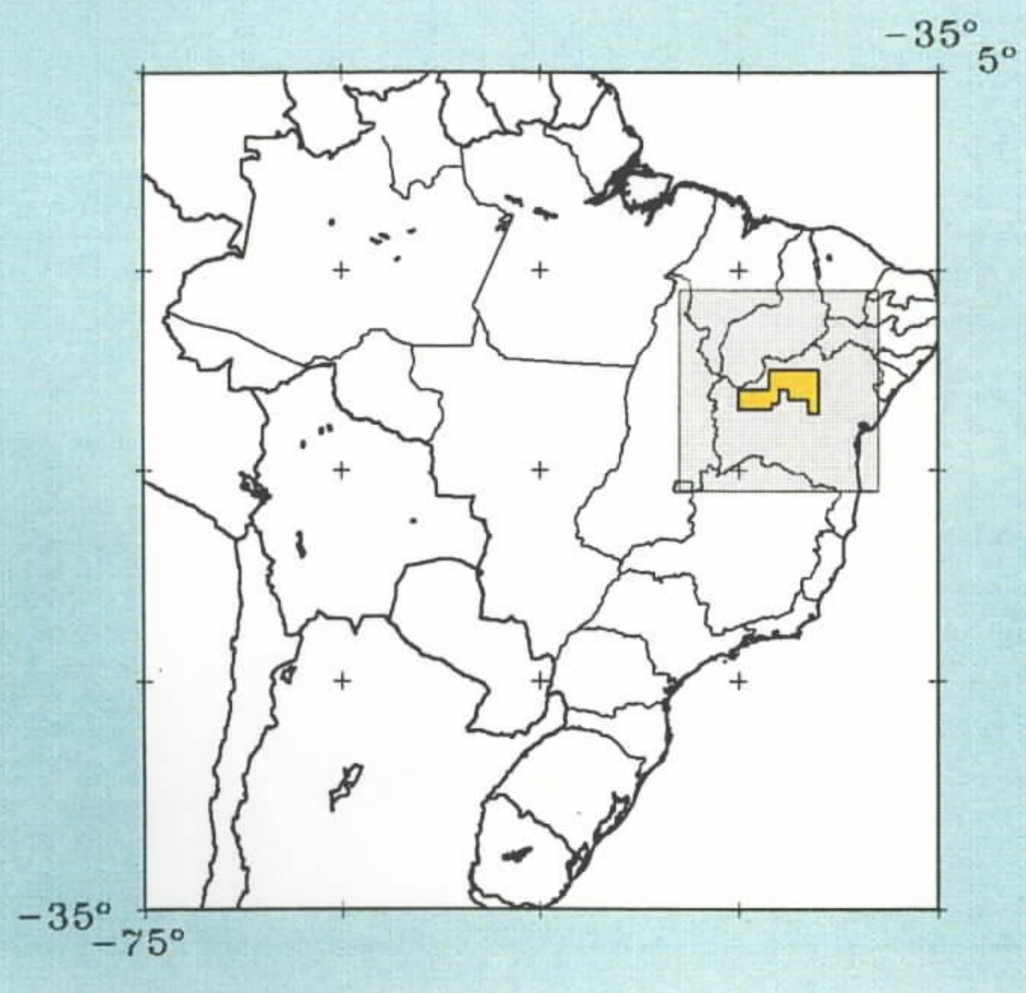
Thorium(Th) (MeV): 2.41 - 2.82
Uranium(U) (MeV): 1.66 - 1.86
Potassium(K) (MeV): 1.36 - 1.56
Total Count(Tc) (MeV): 0.78 - 2.82

Stripping Ratios

Alpha: 0.365
Beta: 0.504
Gamma: 0.778

Comments: -





Norte Da Chapada Diamantina

#1042

SAMMP # **4088** *CPRM #* **1042**

Project	**Norte da Chapada Diamantina**
Client:	**Departamento Nacional da Produção Mineral-DNPM**
Contractor:	**PROSPEC**
Survey Completion Year:	**1979**

Number of Sub-Areas:	2
Total Area (km²)	66 100
Line km:	37 452
Flight Direction:	N-S
Line Spacing (km):	2
Tie Line Spacing (km):	20
Flight Altitude (mtc) (m):	150
Gamma-Spectrometer:	Exploranium DIGRS-3001
Crystal Volume (in³):	830.94
Type of Aircraft:	Islander

Back-Calibrated Sensitivities

Thorium(Th) (cps/ppm):	1.20
Potassium(K) (cps/%):	21.0
Uranium(U) (cps/ppm):	3.0
Total Count(Tc) (cps/dose rate):	69

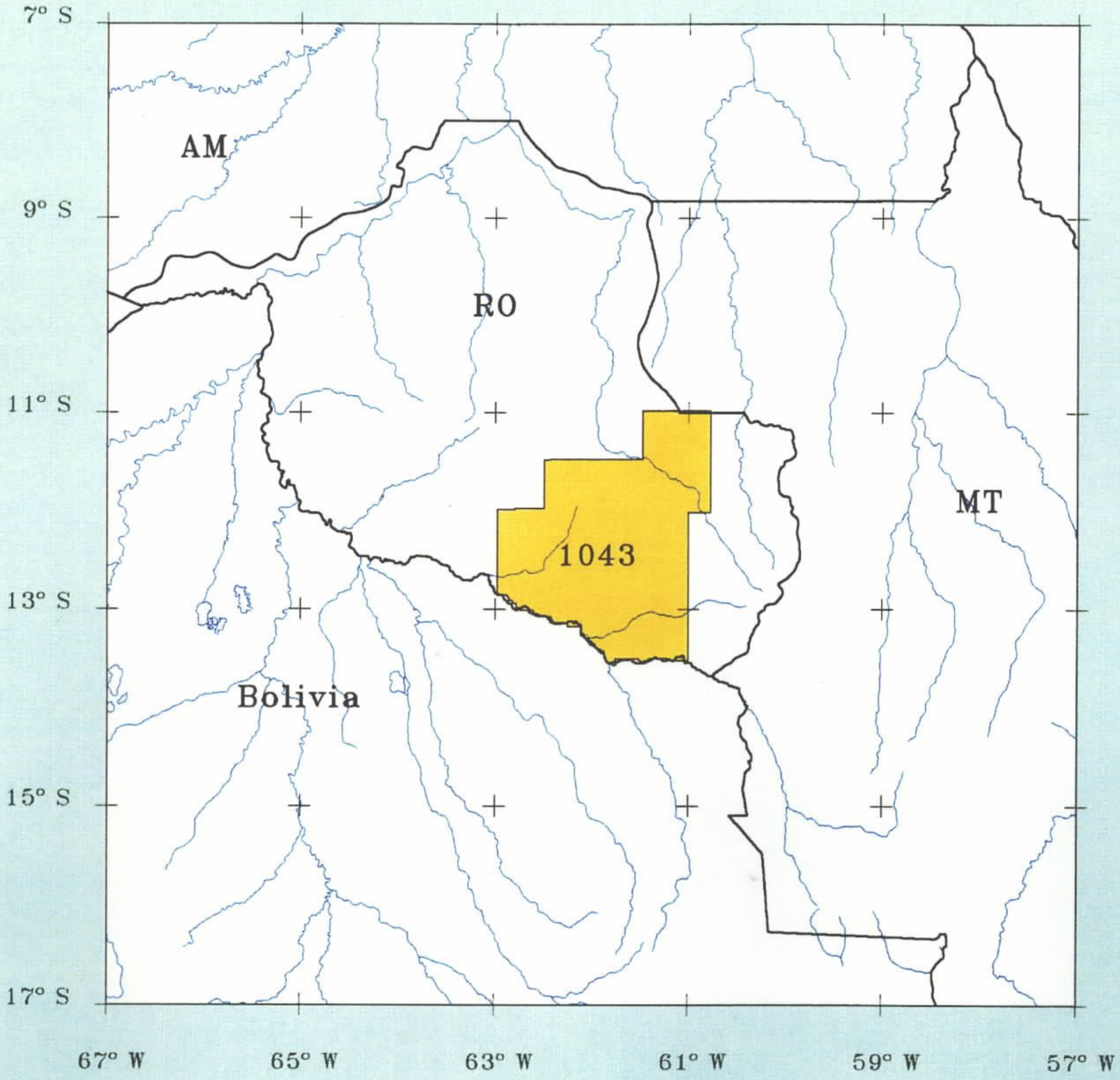
Window Sizes

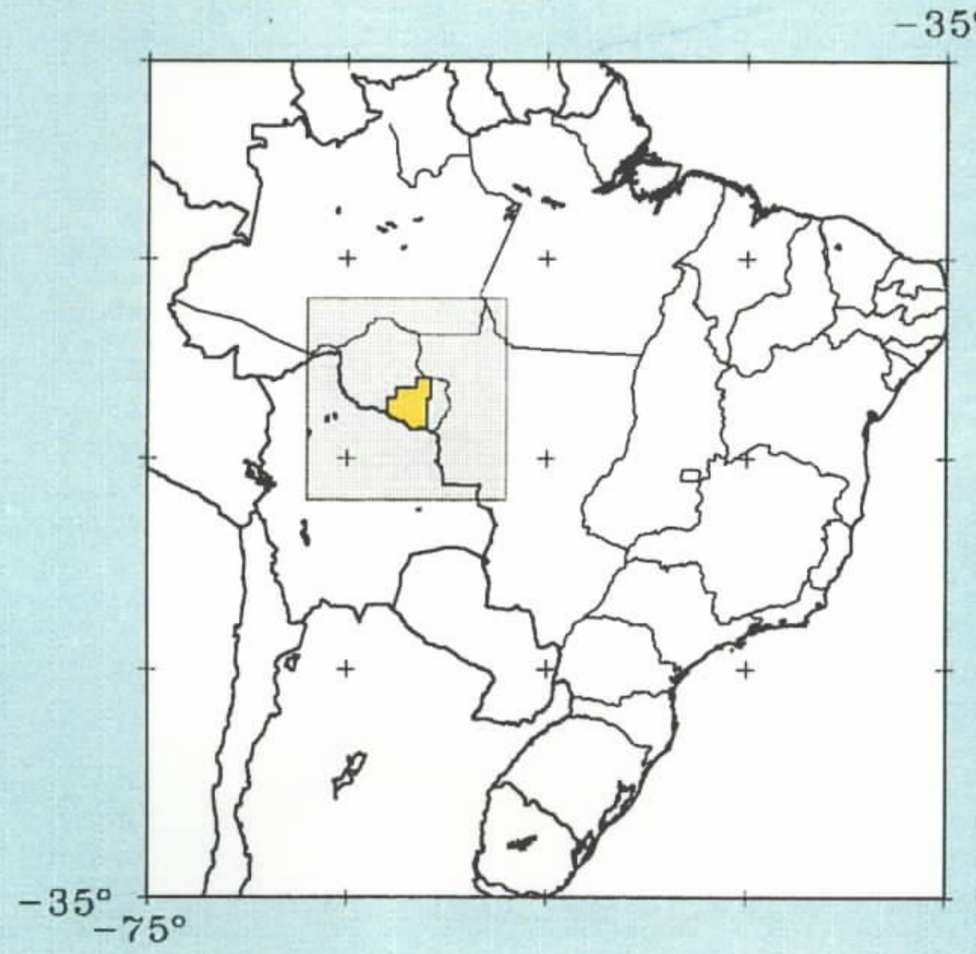
Thorium(Th) (MeV):	2.41 - 2.82	*Uranium(U) (MeV):*	1.66 - 1.86
Potassium(K) (MeV):	1.36 - 1.56	*Total Count(Tc) (MeV):*	0.70 - 2.82

Stripping Ratios

Alpha:	0.367	*Beta:*	0.507
Gamma:	0.781		

Comments: A base noise level of 15 counts was removed from the Total Count before the sensitivity was applied.





Serra Dos Parecis

#1043

SAMMP # **4049** *CPRM #* **1043**

Project	**Serra dos Parecis**
Client:	**Departamento Nacional da Produção Mineral-DNPM**
Contractor:	**GEOFOTO**
Survey Completion Year:	**1979**

Number of Sub-Areas:	1
Total Area (km²):	48 000
Line km:	27 738
Flight Direction:	N-S
Line Spacing (km):	2
Tie Line Spacing (km):	18
Flight Altitude (mtc) (m):	150
Gamma-Spectrometer:	Exploranium DIGRS-3001
Crystal Volume (in³):	1017.87
Type of Aircraft:	Islander

Back-Calibrated Sensitivities

Thorium(Th) (cps/ppm): 1.78
Potassium(K) (cps/%): 25.88
Uranium(U) (cps/ppm): 10.07
Total Count(Tc) (cps/dose rate): 51.79

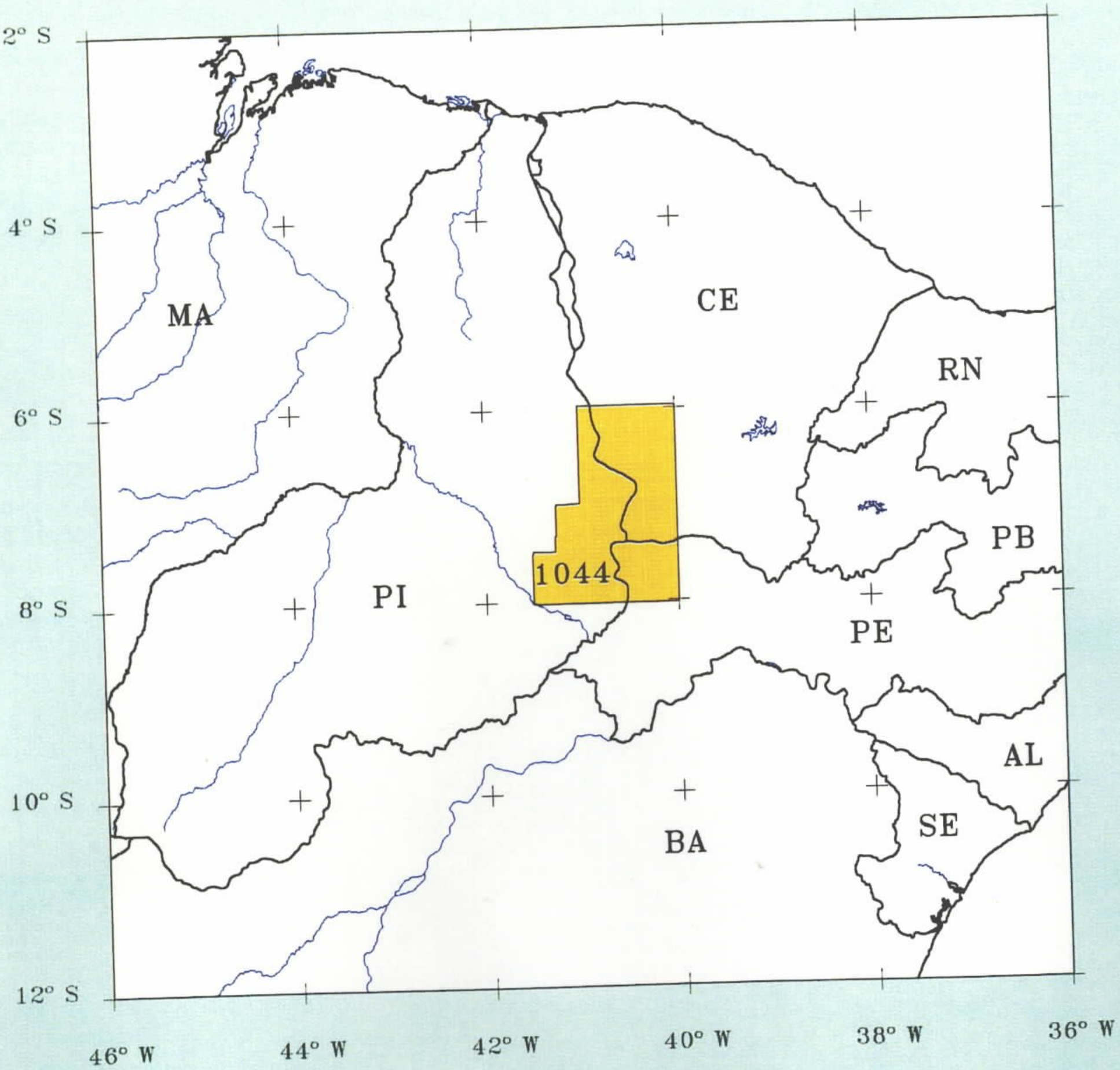
Window Sizes

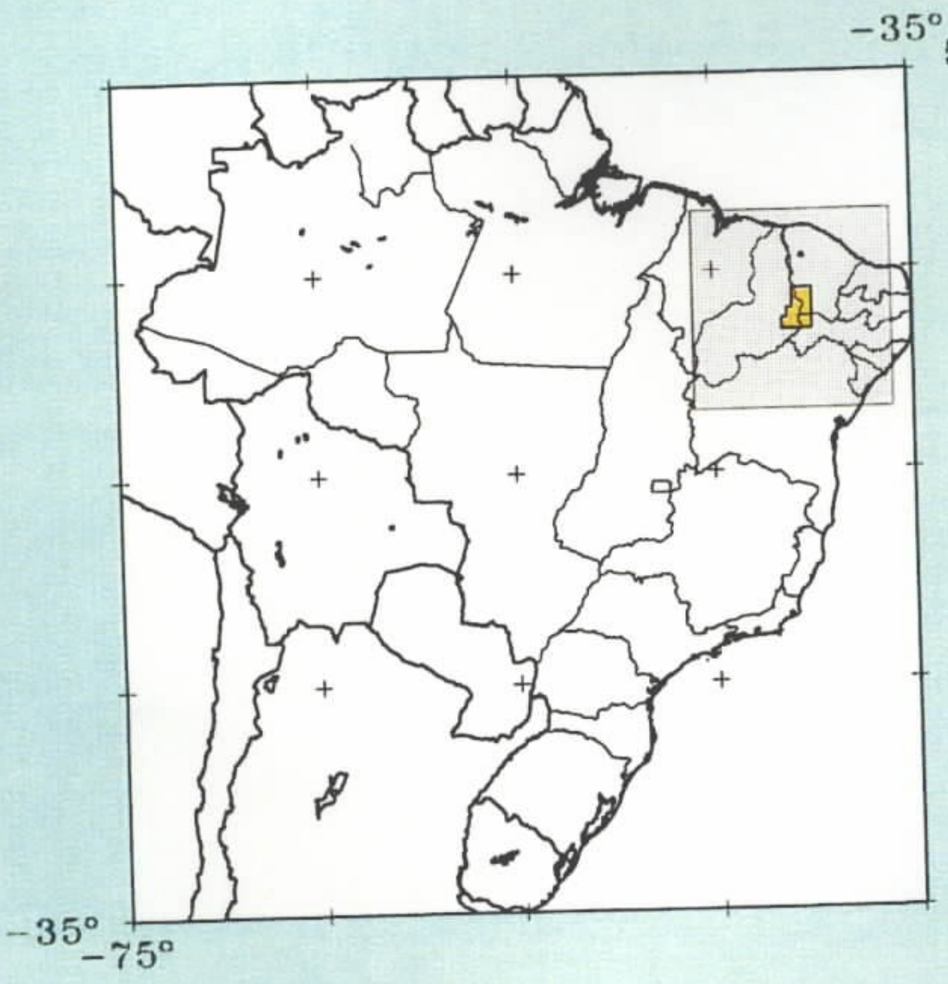
Thorium(Th) (MeV): 2.42 - 2.82
Potassium(K) (MeV): 1.36 - 1.56
Uranium(U) (MeV): 1.68 - 1.88
Total Count(Tc) (MeV): 0.9 - 2.82

Stripping Ratios

Alpha: 0.360
Beta: 0.483
Gamma: 0.754

Comments: -





Borda Leste Da Bacia Do Maranhao

#1044

SAMMP # **4089** *CPRM #* **1044**

Project	**Borda Leste da Bacia do Maranhao**
Client:	**Departamento Nacional da Produção Mineral-DNPM**
Contractor:	**ENCAL**
Survey Completion Year:	**1979**

Number of Sub-Areas:	2
Total Area (km²):	29 000
Line km:	30 400
Flight Direction:	N30W
Line Spacing (km):	1
Tie Line Spacing (km):	20
Flight Altitude (mtc) (m):	150
Gamma-Spectrometer:	Exploranium DIGRS-3001
Crystal Volume (in³):	1024
Type of Aircraft:	Islander

Back-Calibrated Sensitivities

Thorium(Th) (cps/ppm):	1.00
Potassium(K) (cps/%):	21.92
Uranium(U) (cps/ppm):	3.1
Total Count(Tc) (cps/dose rate):	41.55

Window Sizes

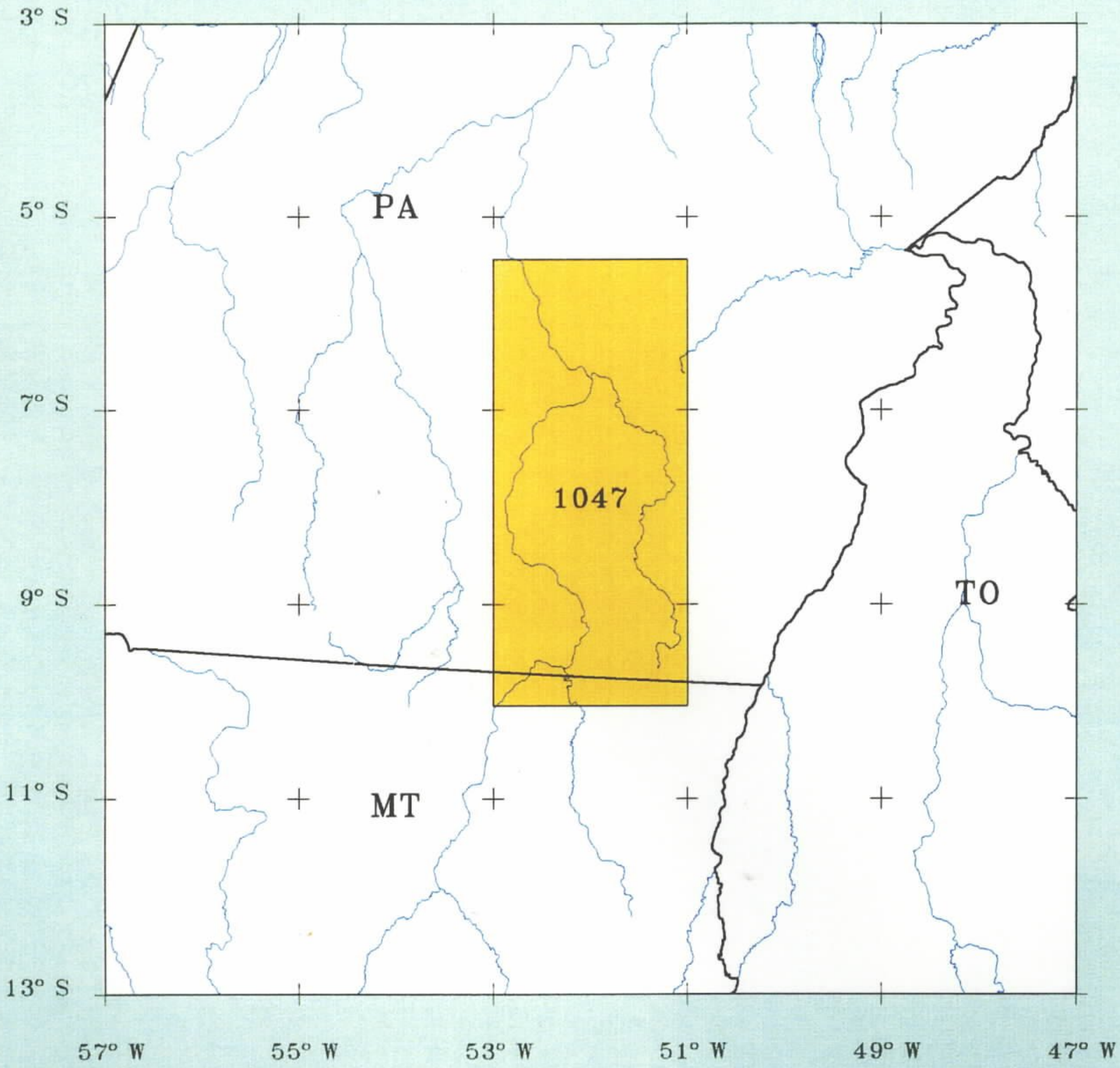
Thorium(Th) (MeV):	2.42 - 2.82	*Uranium(U) (MeV):*	1.66 - 1.86
Potassium(K) (MeV):	1.36 - 1.56	*Total Count(Tc) (MeV):*	0.66 - 2.82

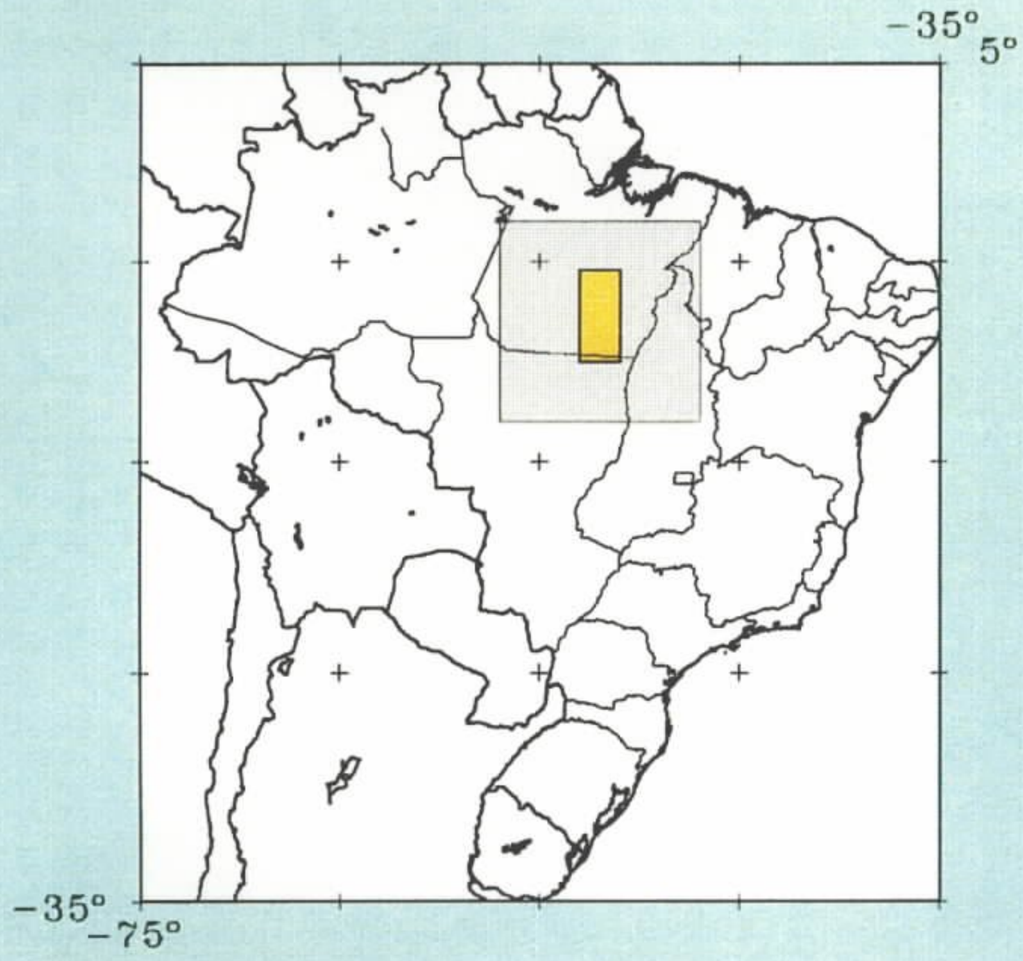
Stripping Ratios

Alpha:	0.306	*Beta:*	0.408
Gamma:	0.704		

Comments: -

45





Carajas (Area 1)

#1047

SAMMP #	**4059**	***CPRM #***	**1047**

Project	**Carajás (Area I)**
Client:	**Departamento Nacional da Produção Mineral-DNPM**
Contractor :	**PROSPEC**
Survey Completion Year:	**1988**

Number of Sub-Areas:	2
Total Area (km^2)	109 765
Line km:	62 214
Flight Direction:	N-S
Line Spacing (km):	2
Tie Line Spacing (km):	20
Flight Altitude (mtc) (m):	150
Gamma-Spectrometer:	Geometrics GR-800
Crystal Volume (in^3)	1024
Type of Aircraft:	Islander

Back-Calibrated Sensitivities

Thorium(Th) (cps/ppm):	1.7(1)	1.7(2)	1.7(3)
Potassium(K) (cps/%):	64(1)	64(2)	64(3)
Uranium(U) (cps/ppm):	1.87(1)	5.5(2)	4.2(3)
Total Count(Tc) (cps/dose rate):	90(1)	90(2)	90(3)

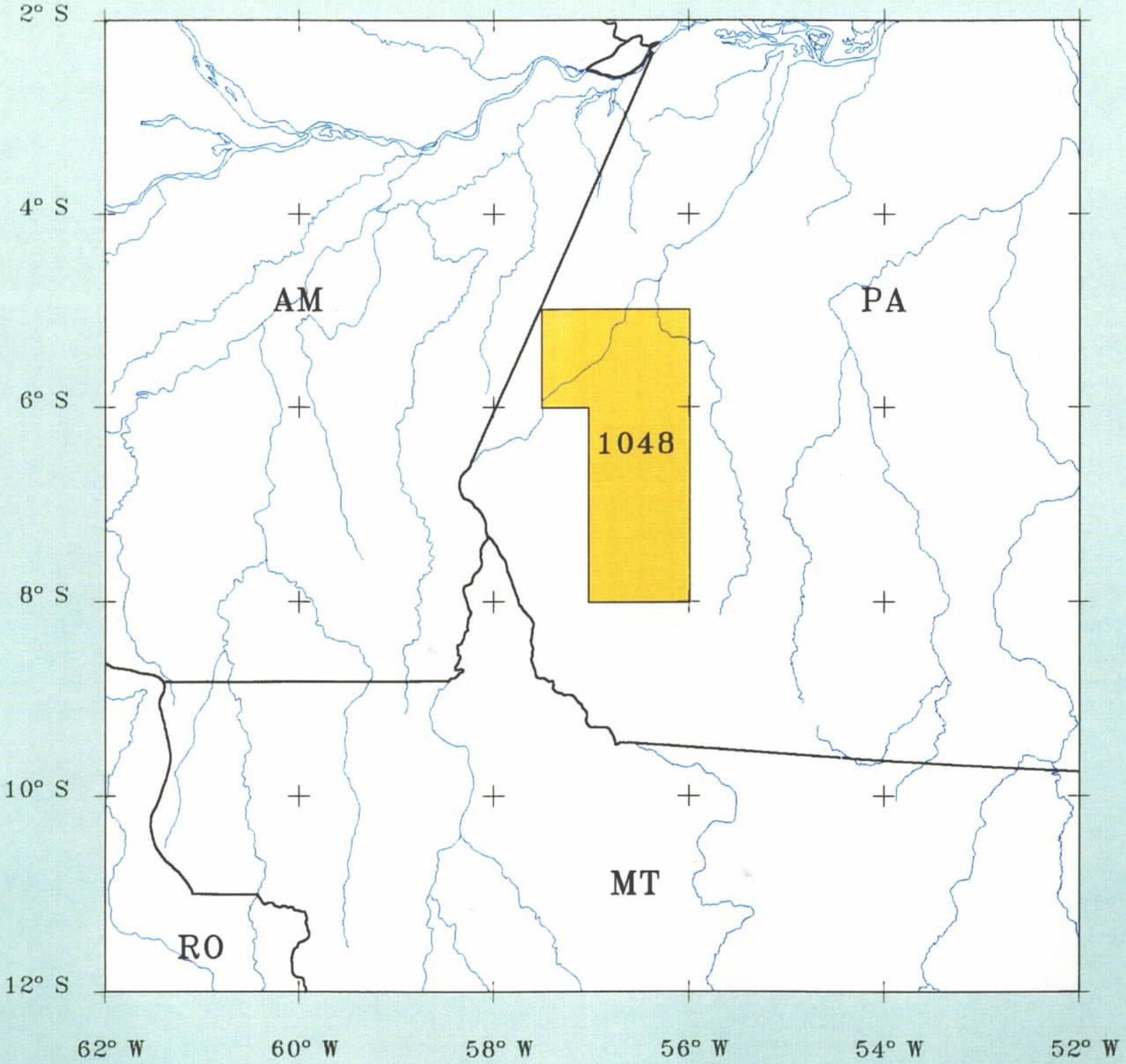
Window Sizes

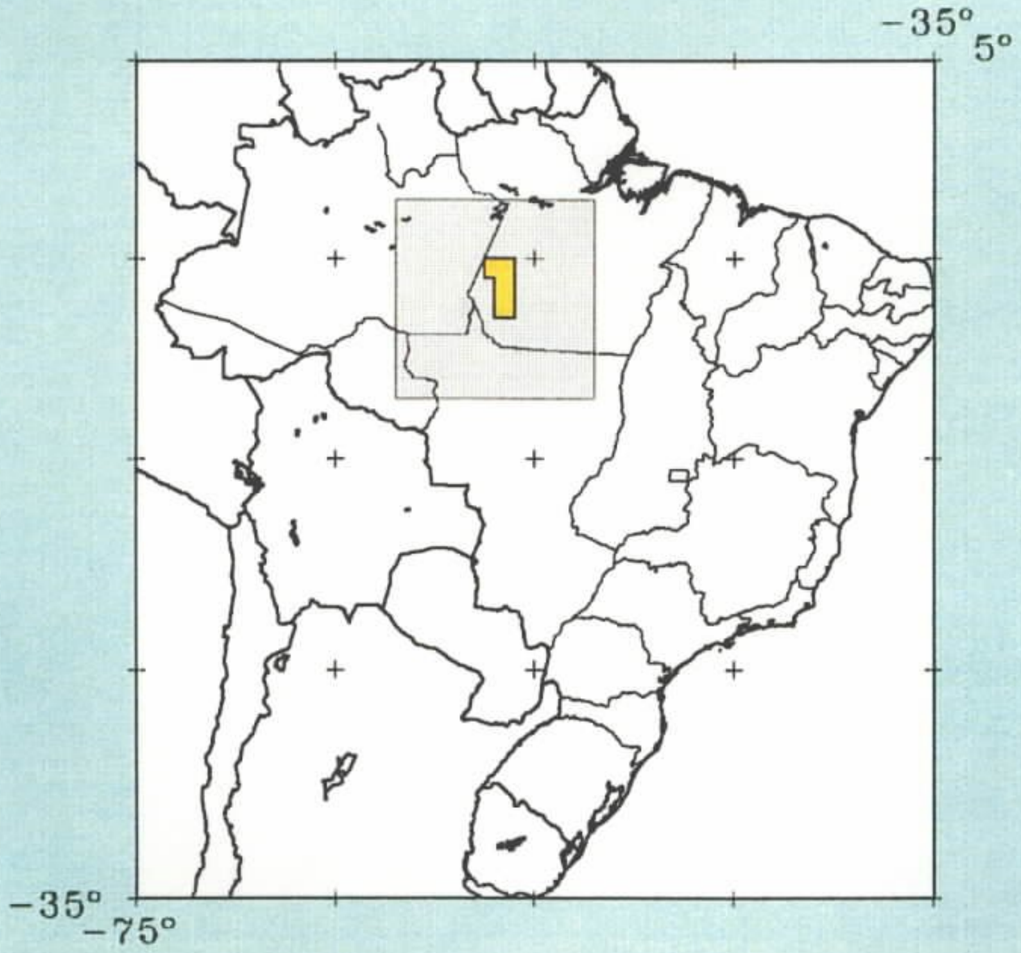
Thorium(Th) (MeV):	2.42 - 2.82	***Uranium(U) (MeV):***	1.66 - 1.86
Potassium(K) (MeV):	1.36 - 1.56	***Total Count(Tc) (MeV):***	0.40 - 2.82

Stripping Ratios

Alpha:	0.45	***Beta:***	0.22
Gamma:	0.90		0.339
	0.225		
	0.747		

Comments: A base noise level in counts was removed from the data before the sensitivities were applied. Th-6, K(1)-25, U(2)-13, Tc-300.
Survey flown in three parts: Parts (1) and (2) north of 9° south was phase I,
Part (3) south of 9° south was phase II.





Medio Tapajos

#1048

SAMMP #	**4056**	*CPRM #*	**1048**

Project	**Médio Tapajós**
Client :	**Departamento Nacional da Produção Mineral-DNPM**
Contractor:	**LASA**
Survey Completion Year:	**1987**

Number of Sub-Areas:	2
Total Area (km²):	43 000
Line km:	24 478
Flight Direction:	N-S
Line Spacing (km):	2
Tie Line Spacing (km):	20
Flight Altitude (mtc) (m):	150
Gamma-Spectrometer:	Exploranium DIGRS-3001
Crystal Volume (in³):	1024
Type of Aircraft:	Islander

Back-Calibrated Sensitivities

Thorium(Th) (cps/ppm):	1.33
Potassium(K) (cps/%):	23.5
Uranium(U) (cps/ppm):	2.14
Total Count(Tc) (cps/dose rate):	56.32

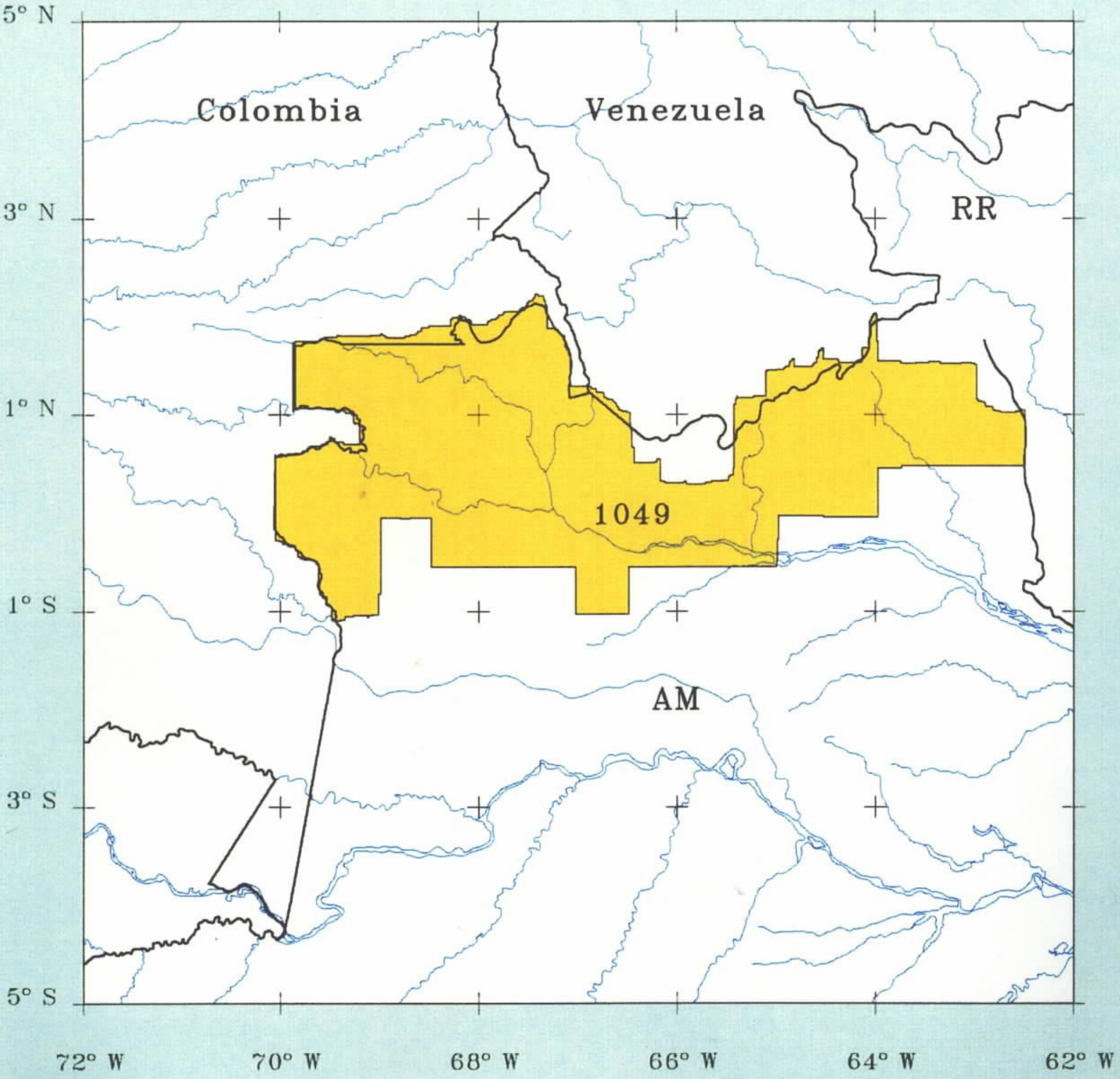
Window Sizes

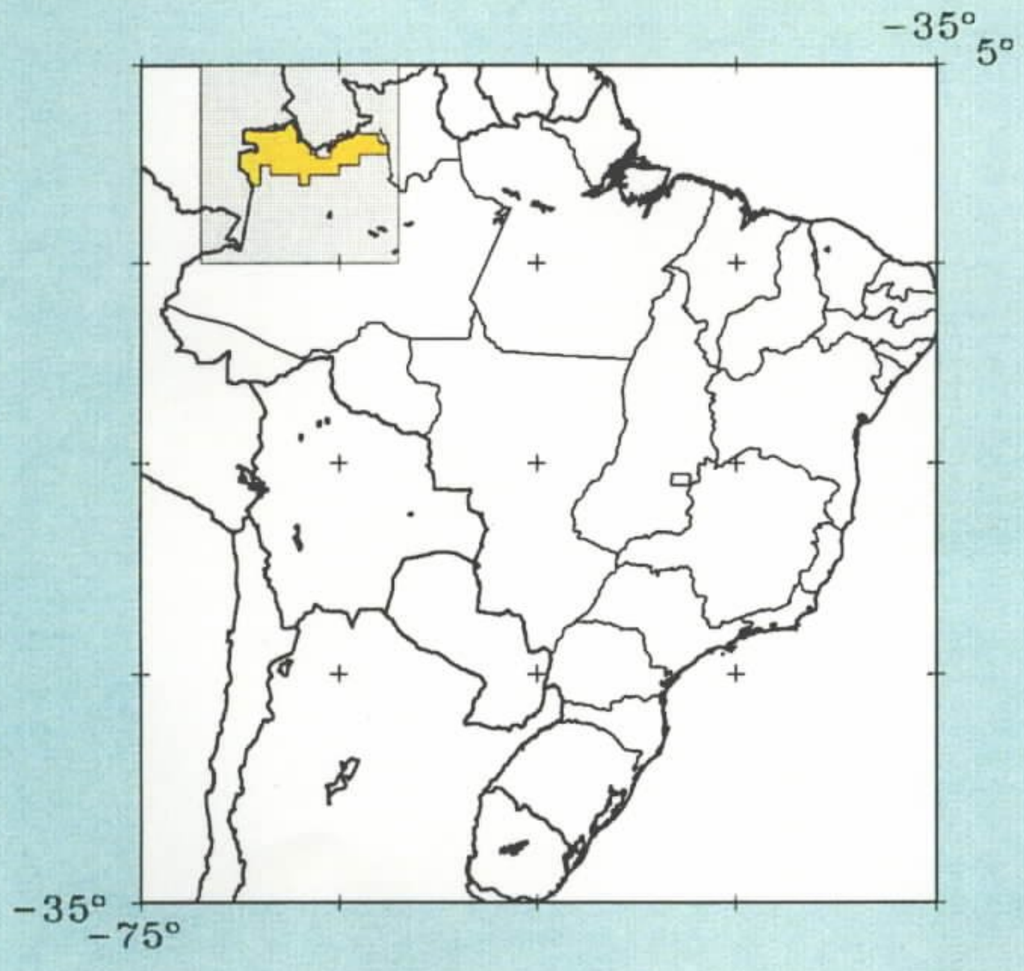
Thorium(Th) (MeV):	2.42 - 2.82	*Uranium(U) (MeV):*	1.66 - 1.86
Potassium(K) (MeV):	1.36 - 1.56	*Total Count(Tc) (MeV):*	0.40 - 2.82

Stripping Ratios

Alpha:	0.365	*Beta:*	0.500
Gamma:	0.770		

Comments: -





Extremo-Noroeste Do Brasil

#1049

SAMMP # **4053** *CPRM #* **1049**

Project	**Extremo-Noroeste do Brasil**
Client:	**Departamento Nacional da Produção Mineral-DNPM**
Contractor :	**ENCAL**
Survey Completion Year:	**1988**

Number of Sub-Areas:	6	
Total Area (km²):	150 000	
Line km:	86 620	
Flight Direction:	N-S	
Line Spacing (km):	2	
Tie Line Spacing (km):	20	
Flight Altitude (mtc) (m):	150	
Gamma-Spectrometer:	Exploranium DIGRS-3001	Geometrics GR-800A
Crystal Volume (in³):	1024	
Type of Aircraft:	Islander	

Back-Calibrated Sensitivities

Thorium(Th) (cps/ppm):	2.3
Potassium(K) (cps/%):	21.92
Uranium(U) (cps/ppm):	5.5
Total Count(Tc) (cps/dose rate):	64.0

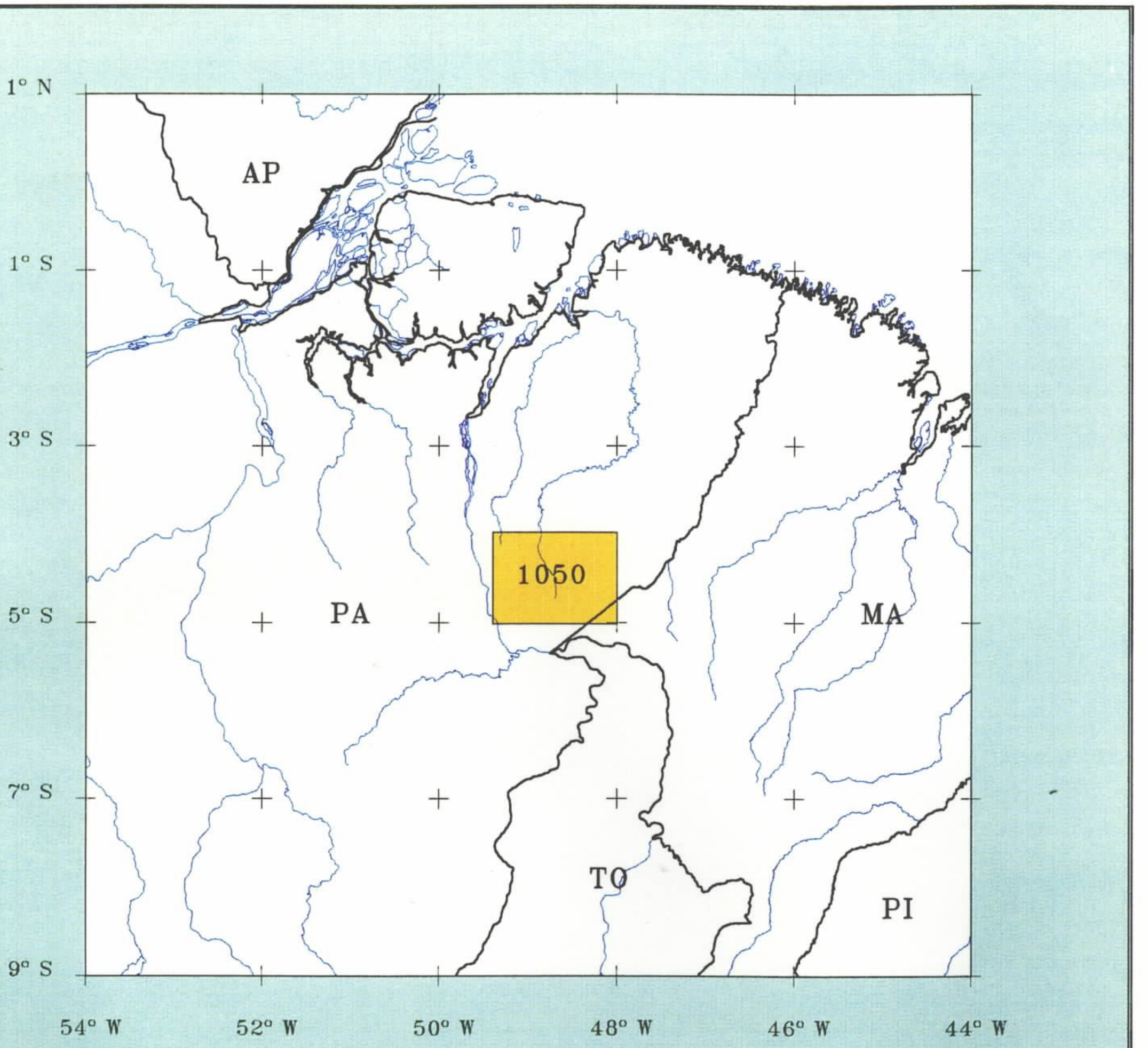
Window Sizes

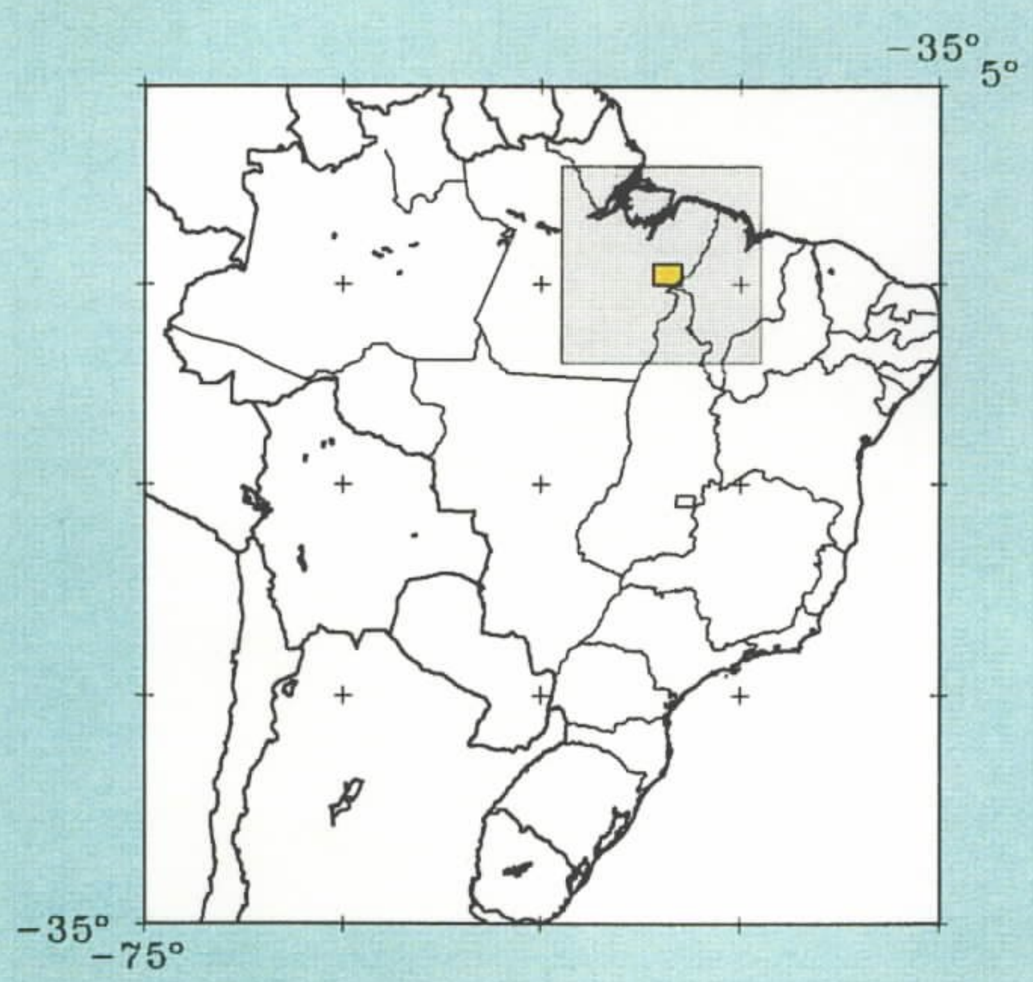
Thorium(Th) (MeV):	2.42 - 2.82	*Uranium(U) (MeV):*	1.66 - 1.86
Potassium(K) (MeV):	1.36 - 1.56	*Total Count(Tc) (MeV):*	0.40 - 2.82

Stripping Ratios

Alpha:	0.365	*Beta:*	0.484
Gamma:	0.752		

Comments: This survey used two different gamma spectrometers.





Carajas (Area 2)

#1050

82

SAMMP # **4057** *CPRM #* **1050**

Project	**Carajás (Area II)**
Client:	**Departamento Nacional da Produção Mineral-DNPM**
Contractor:	**PROSPEC**
Survey Completion Year:	**1988**

Number of Sub-Areas:	1
Total Area (km²):	18 408
Line km:	10 480
Flight Direction:	N-S
Line Spacing (km):	2
Tie Line Spacing (km):	20
Flight Altitude (mtc) (m):	150
Gamma-Spectrometer:	Exploranium DIGRS-3001
Crystal Volume (in³):	1024
Type of Aircraft:	Islander

Back-Calibrated Sensitivities

Thorium(Th) (cps/ppm): 1.33
Potassium(K) (cps/%): 38
Uranium(U) (cps/ppm): 4.5
Total Count(Tc) (cps/dose rate): 73

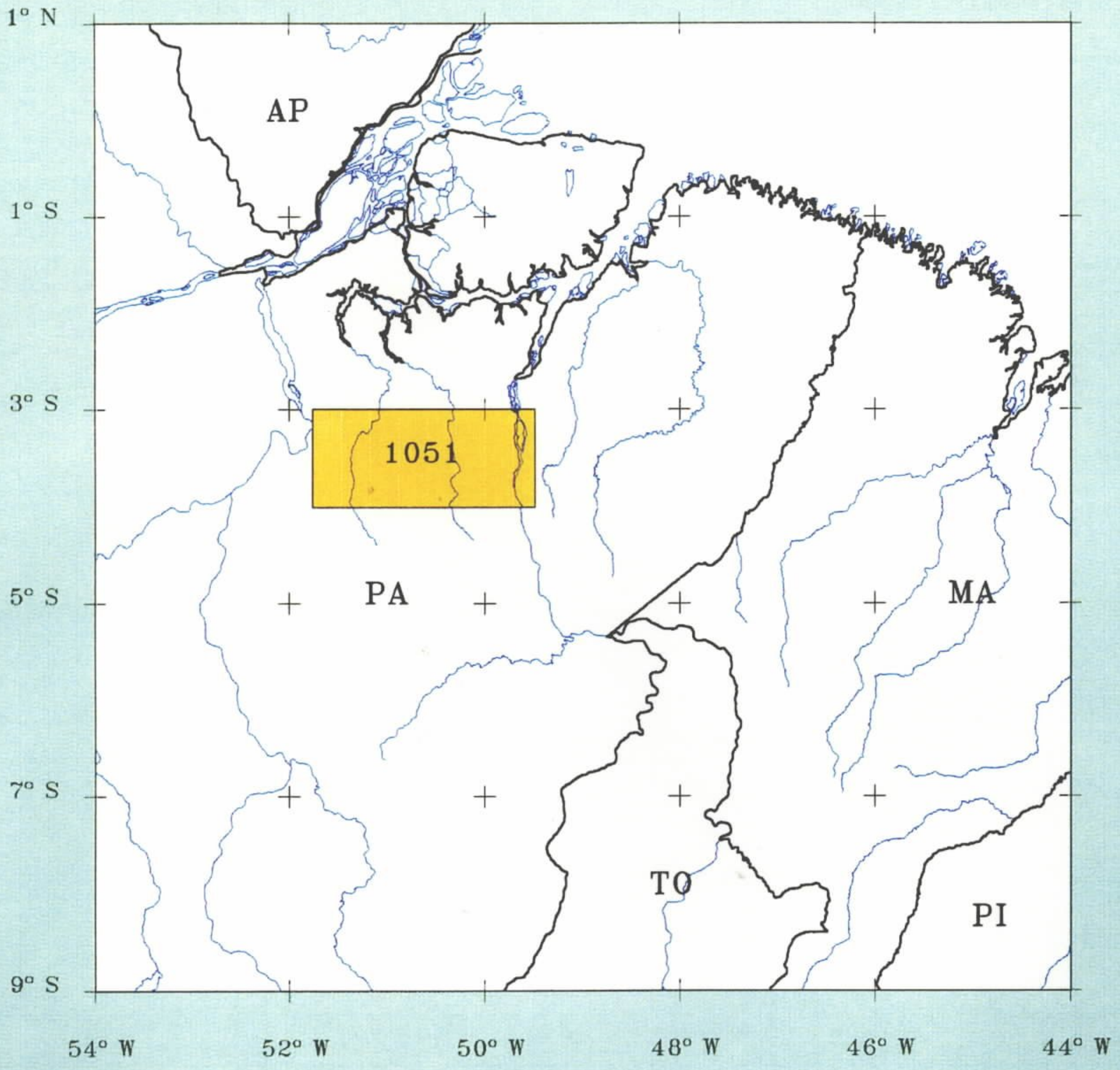
Window Sizes

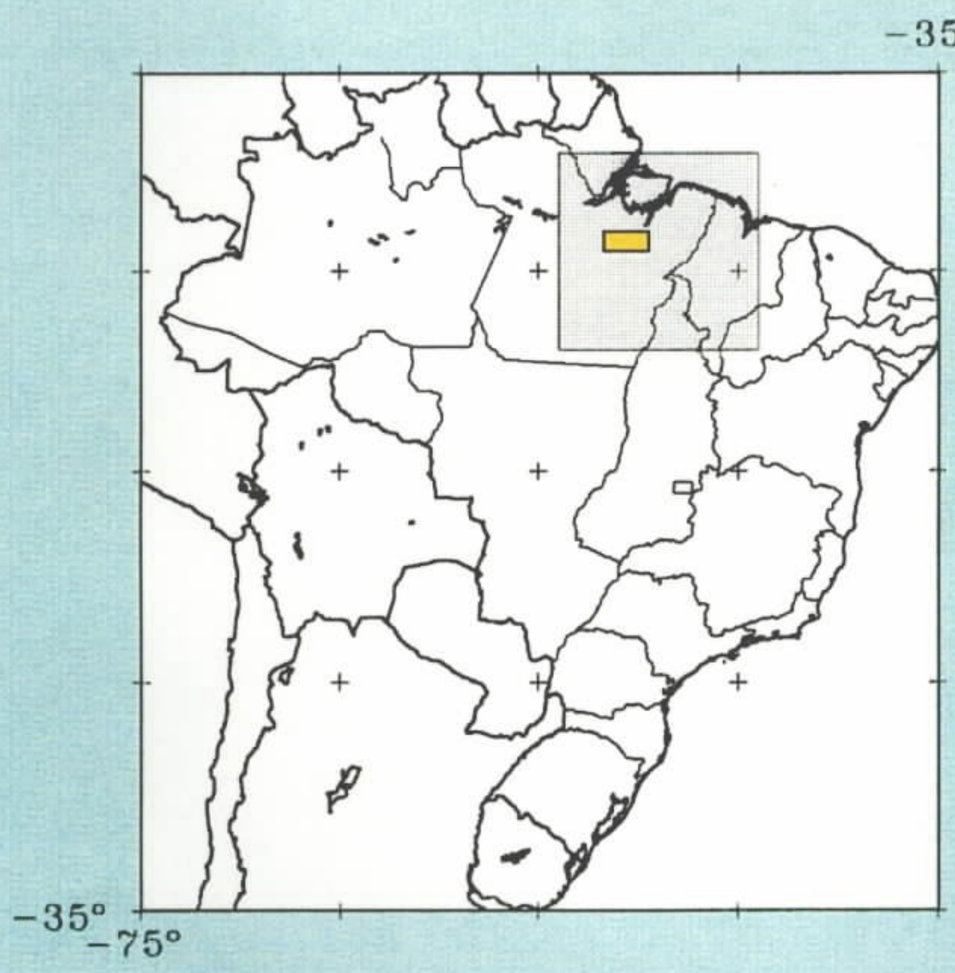
Thorium(Th) (MeV): 2.42 - 2.82
Uranium(U) (MeV): 1.66 - 1.86
Potassium(K) (MeV): 1.36 - 1.56
Total Count(Tc) (MeV): 0.40 - 2.82

Stripping Ratios

Alpha: 0.365
Beta: 0.50
Gamma: 0.77

Comments: -





Carajas (Area 3)

#1051

SAMMP # **4058** *CPRM #* **1051**

Project	**Carajás (Area III)**
Client:	**Departamento Nacional da Produção Mineral-DNPM**
Contractor:	**PROSPEC**
Survey Completion Year:	**1987**

Number of Sub-Areas:	1
Total Area (km²):	27 646
Line km:	15 604
Flight Direction:	N-S
Line Spacing (km):	2
Tie Line Spacing (km):	20
Flight Altitude (mtc) (m):	150
Gamma-Spectrometer:	Exploranium DIGRS-3001
Crystal Volume (in³):	1024
Type of Aircraft:	Islander

Back-Calibrated Sensitivities

Thorium(Th) (cps/ppm):	1.33
Potassium(K) (cps/%):	25
Uranium(U) (cps/ppm):	2.5
Total Count(Tc) (cps/dose rate):	73

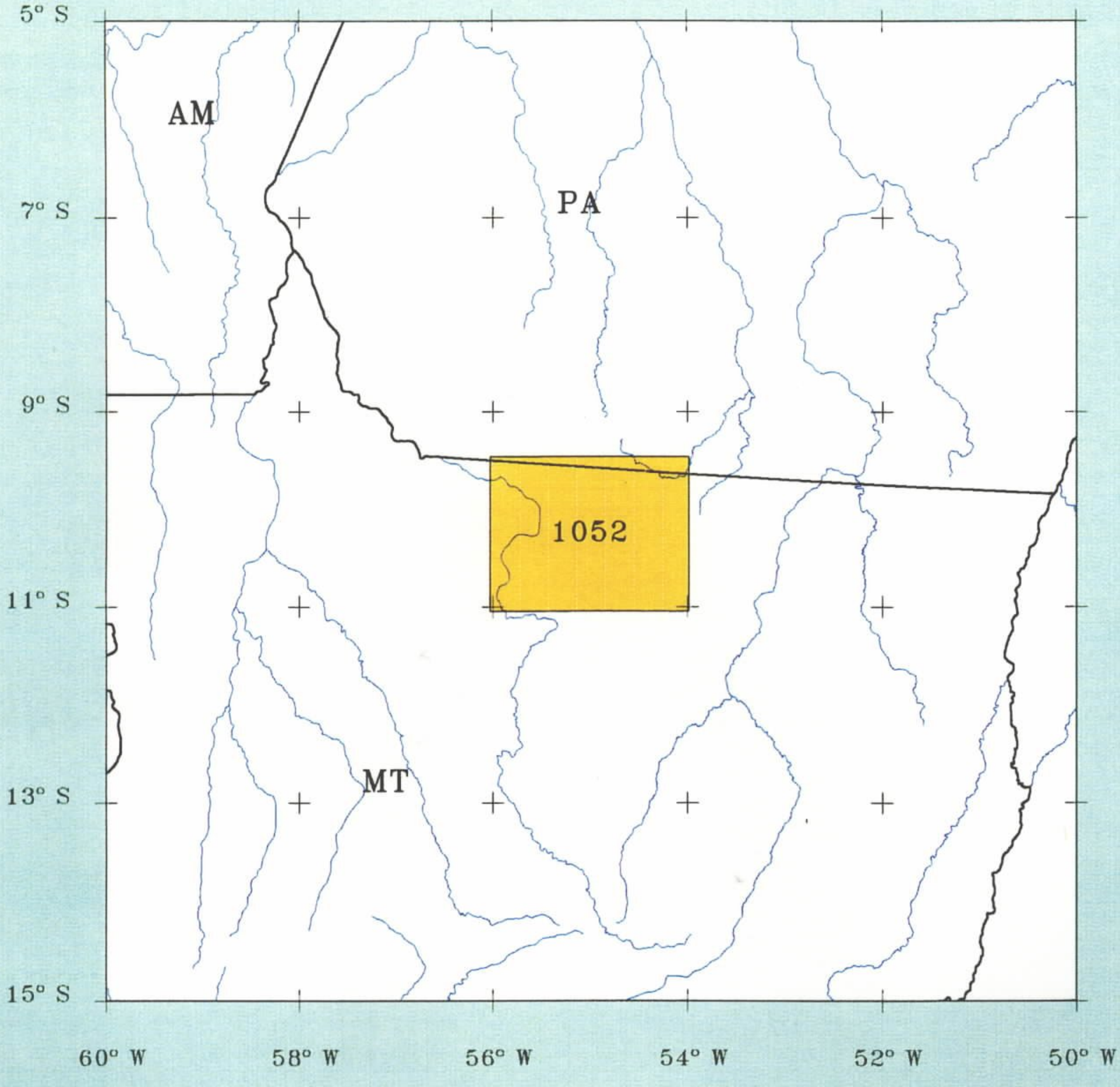
Window Sizes

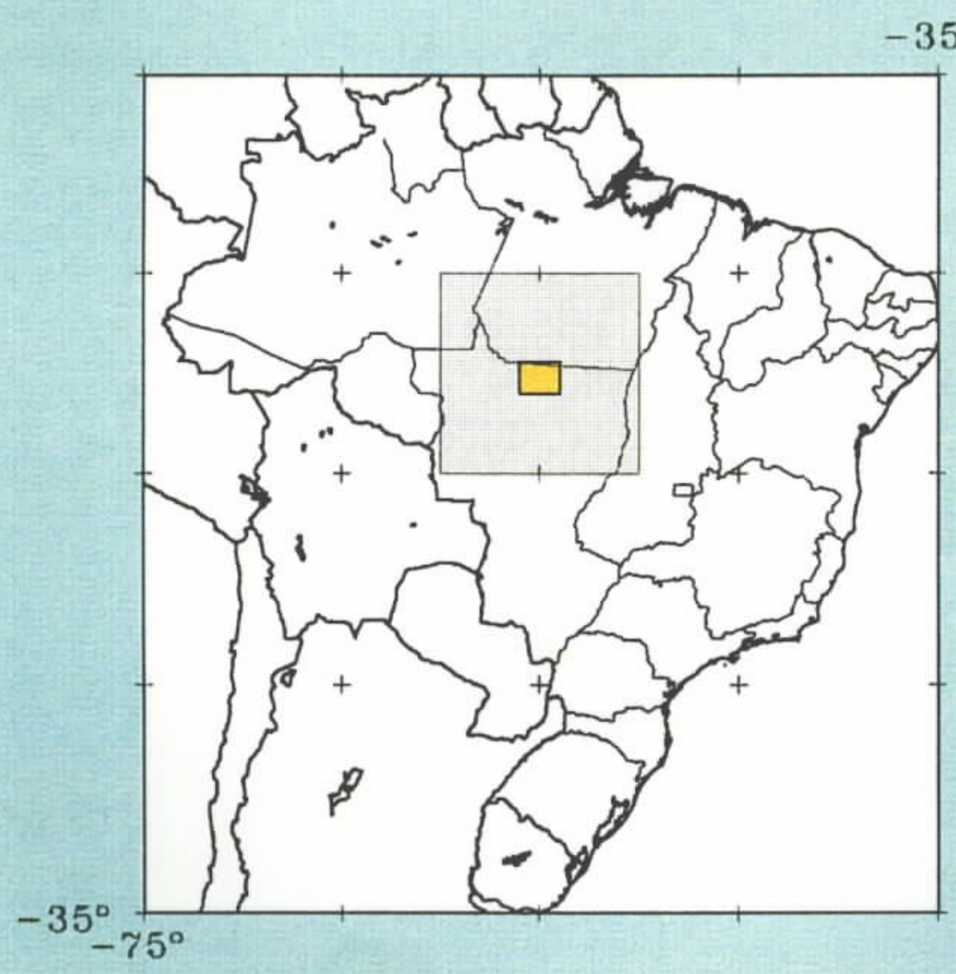
Thorium(Th) (MeV):	2.42 - 2.82	*Uranium(U) (MeV):*	1.66 - 1.86
Potassium(K) (MeV):	1.36 - 1.56	*Total Count(Tc) (MeV):*	0.40 - 2.82

Stripping Ratios

Alpha:	0.365	*Beta:*	0.50
Gamma:	0.77		

Comments: -





Juruena–Teles Pires
(phase 1)

#1052

SAMMP # **4055** *CPRM #* **1052**

Project	**Juruena-Teles Pires (phase I)**
Client:	**Companhia de Pesquisa de Recursos Minerais-CPRM**
Contractor:	**ENCAL/PROSPEC**
Survey Completion Year:	**1991**

Number of Sub-Areas:	1
Total Area (km²):	36 300
Line km:	21 536
Flight Direction:	N-S
Line Spacing (km):	2
Tie Line Spacing (km):	18
Flight Altitude (mtc) (m):	150
Gamma-Spectrometer:	Geometrics GR-800
Crystal Volume (in³)	1024
Type of Aircraft:	Islander

Back-Calibrated Sensitivities

Thorium(Th) (cps/ppm):	2.2
Potassium(K) (cps/%):	21.92
Uranium(U) (cps/ppm):	3.2
Total Count(Tc) (cps/dose rate):	23.6

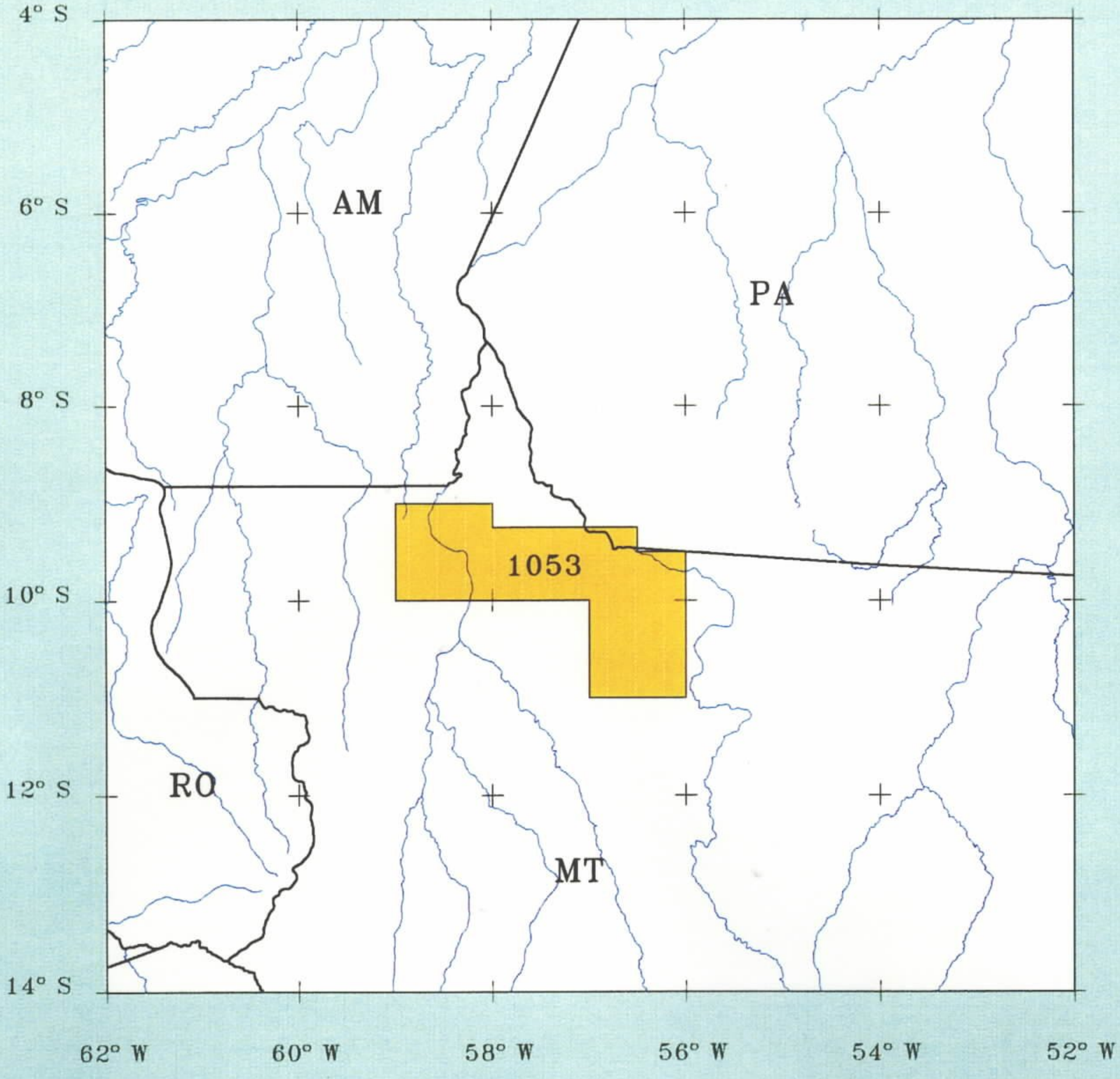
Window Sizes

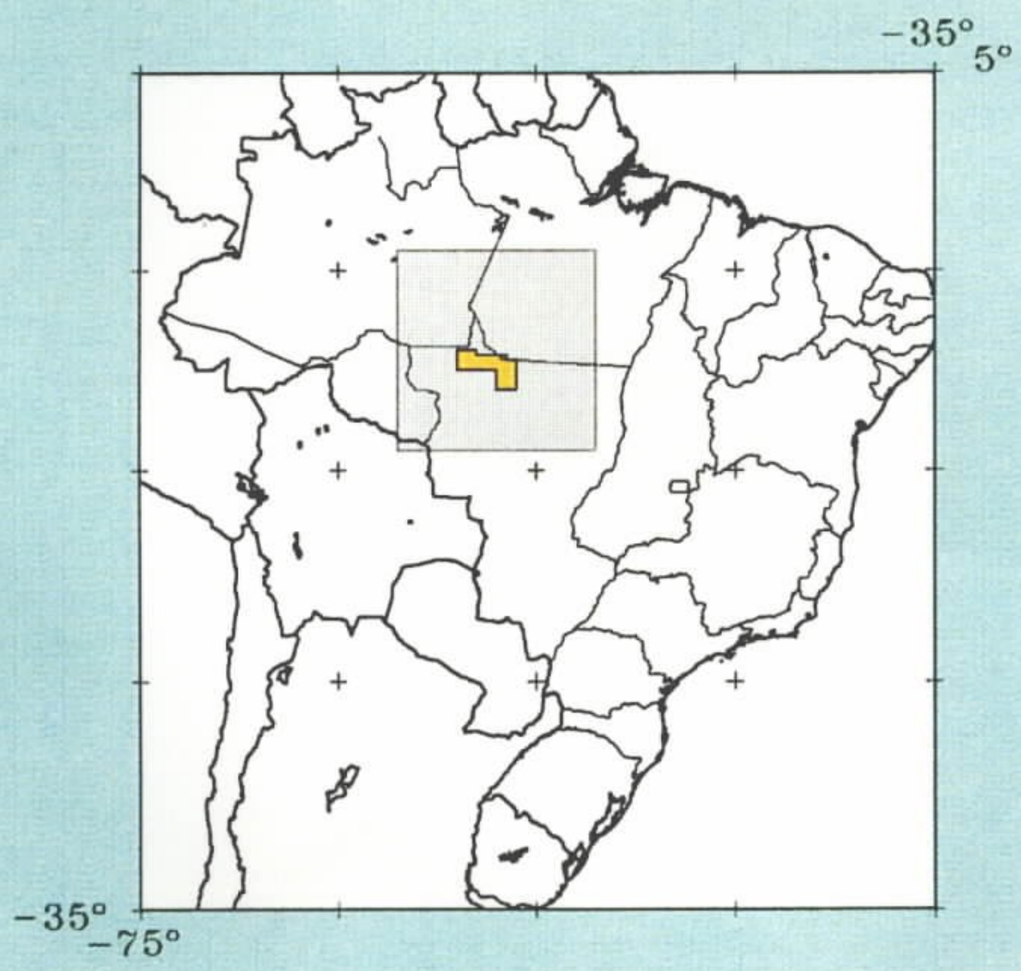
Thorium(Th) (MeV):	2.42 - 2.82	*Uranium(U) (MeV):*	1.66 - 1.86
Potassium(K) (MeV):	1.36 - 1.56	*Total Count(Tc) (MeV):*	0.40 - 2.82

Stripping Ratios

Alpha:	0.258 0.272	*Beta:*	0.202 0.173
Gamma:	0.783 0.845		

Comments: A base noise level of 3 counts was removed from the thorium data before the sensitivity was applied.





Juruena–Teles Pires
(phase 2)

#1053

SAMMP # *CPRM #* **1053**

Project	**Juruena-Teles Pires (phase 2)**
Client:	**Companhia de Pesquisa de Recursos Minerais-CPRM**
Contractor:	**GEOMAG**
Survey Completion Year:	**1996**

Number of Sub-Areas:	1
Total Area (km^2):	42 000
Line km:	21 000
Flight Direction:	N-S
Line Spacing (km):	2
Tie Line Spacing (km):	20
Flight Altitude (mtc) (m):	150
Gamma-Spectrometer:	Exploranium GR-820
Crystal Volume (in^3):	1024
Type of Aircraft:	Islander

Back-Calibrated Sensitivities

Thorium(Th) (cps/ppm):	2.2
Potassium(K) (cps/%):	21.92
Uranium(U) (cps/ppm):	4.0
Total Count(Tc) (cps/dose rate):	85.0

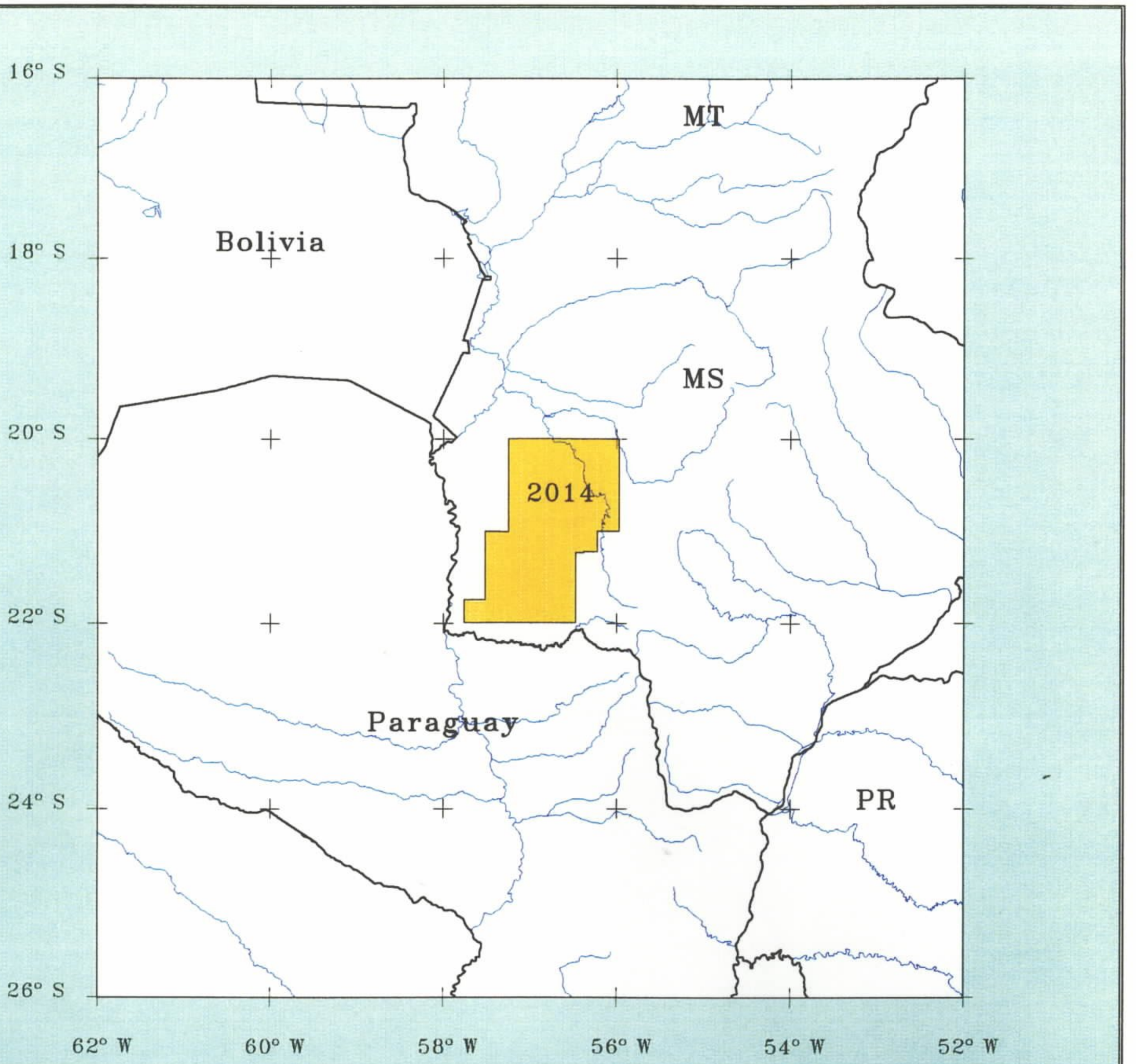
Window Sizes

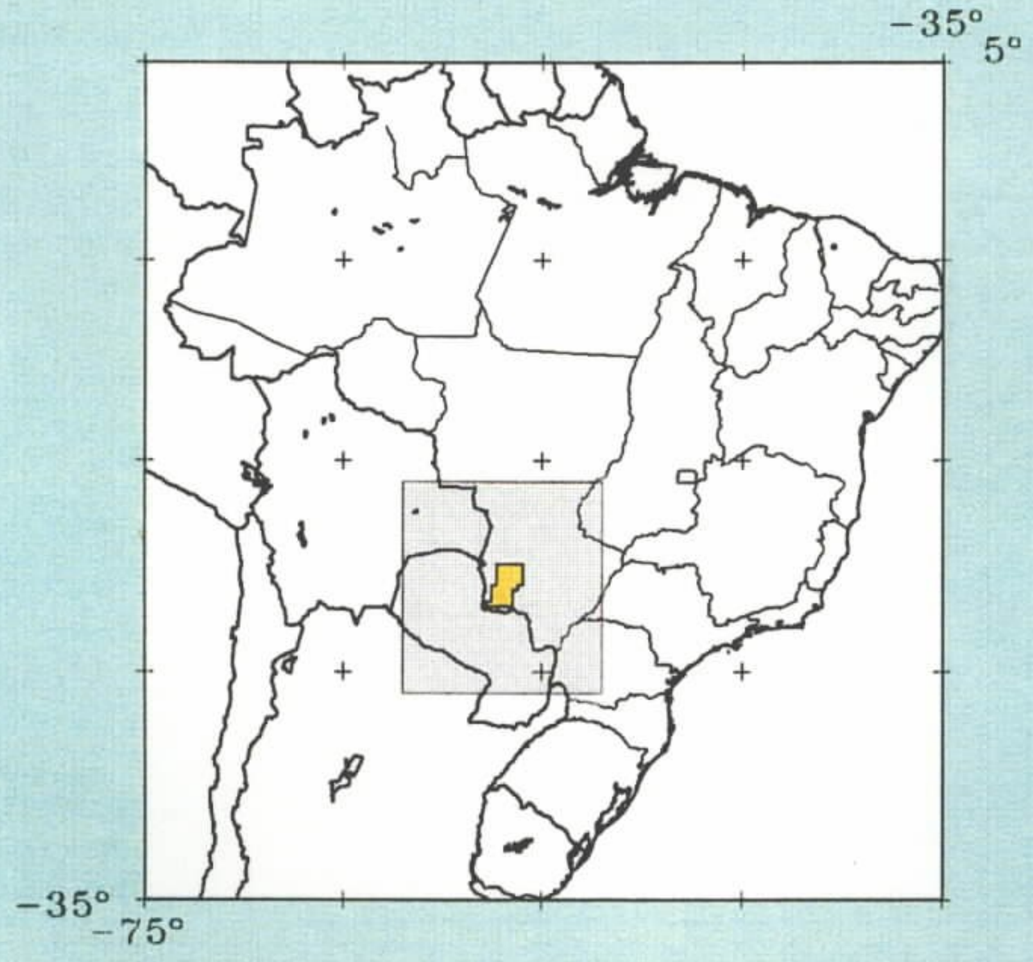
Thorium(Th) (MeV):	2.42 - 2.82	***Uranium(U) (MeV):***	1.66 - 1.86
Potassium(K) (MeV):	1.36 - 1.56	***Total Count(Tc) (MeV):***	0.40 - 2.82

Stripping Ratios

Alpha:	0.257	***Beta:***	0.421
Gamma:	0.722		

Comments: A base noise level in counts was removed from the data before the sensitivities were applied. Th-3 and U-1.





Bodoquena

#2014

SAMMP #	**4204**	***CPRM #***	**2014**

Project	**Bodoquena**
Client:	**Comissão Nacional de Energia Nuclear-CNEN/DNPM**
Contractor:	**GEOFOTO**
Survey Completion Year:	**1975**

Number of Sub-Areas:	1
Total Area (km²):	24 000
Line km:	14 590
Flight Direction:	E-W
Line Spacing (km):	2
Tie Line Spacing (km):	20
Flight Altitude (mtc) (m):	150
Gamma-Spectrometer:	Exploranium DIGRS-3001
Crystal Volume (in³):	1017.87
Type of Aircraft:	Islander

Back-Calibrated Sensitivities

Thorium(Th) (cps/ppm):	1.78
Potassium(K) (cps/%):	40.0
Uranium(U) (cps/ppm):	15.0
Total Count(Tc) (cps/dose rate):	20.0

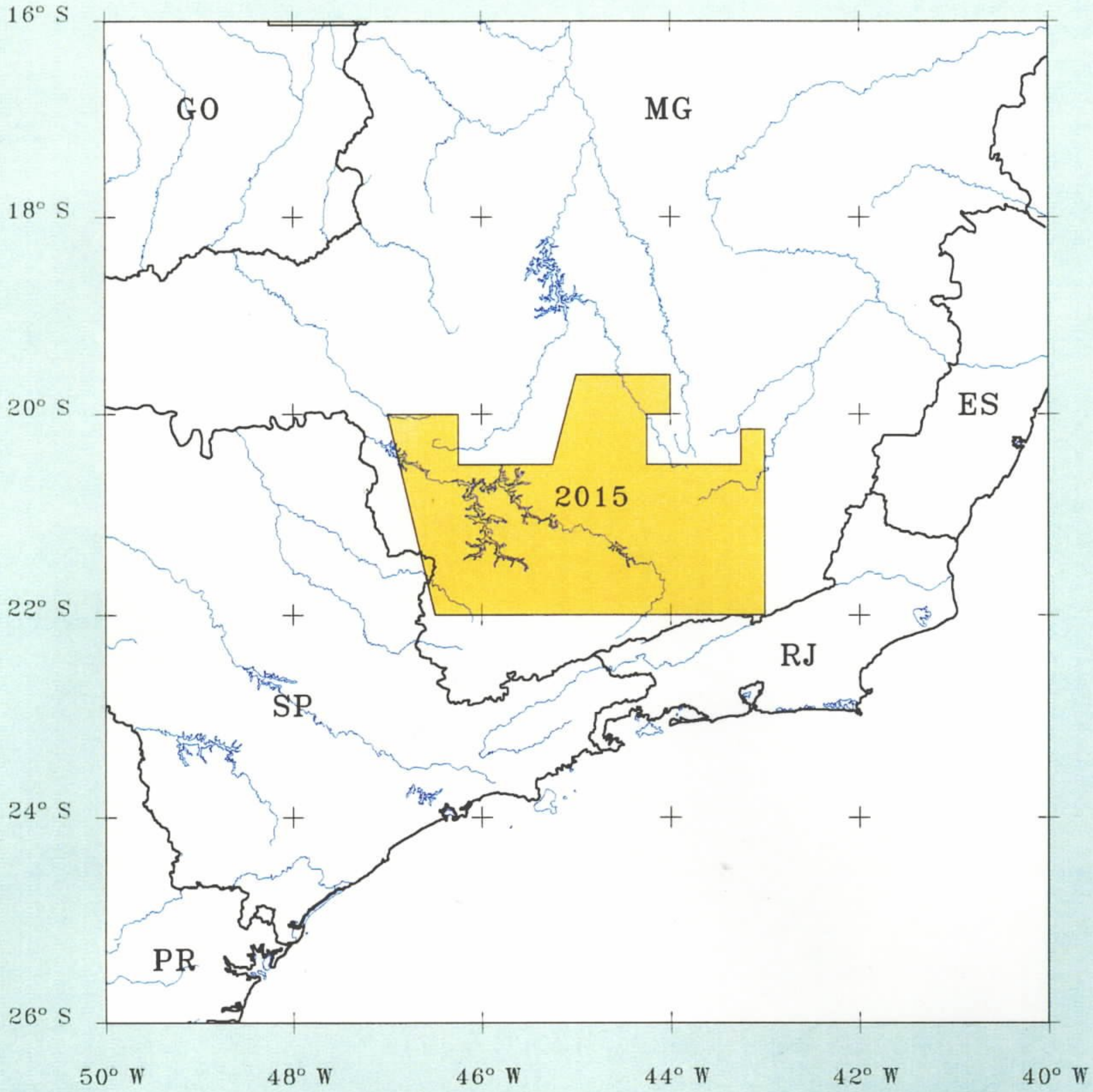
Window Sizes

Thorium(Th) (MeV):	***Uranium(U) (MeV):***
Potassium(K) (MeV):	***Total Count(Tc) (MeV):***

Stripping Ratios

Alpha: 0.35	***Beta:*** 0.33
Gamma: 0.56	

Comments: -


16° S
18° S
20° S
22° S
24° S
26° S
50° W
48° W
46° W
44° W
42° W
40° W
GO
MG
ES
RJ
SP
PR
2015


−35°
5°
−35°
−75°

Furnas

#2015

SAMMP #	***CPRM #*** **2015**
Project	**Furnas**
Client:	**Comissão Nacional de Energia Nuclear-CNEN**
Contractor:	**PROSPEC**
Survey Completion Year:	**1975**
Number of Sub-Areas:	1
Total Area (km²):	76 000
Line km:	24 400
Flight Direction:	N-S
Line Spacing (km):	4
Tie Line Spacing (km):	20
Flight Altitude (mtc) (m):	150
Gamma-Spectrometer:	Exploranium DIGRS-3001
Crystal Volume (in³):	830.94
Type of Aircraft:	Islander

<u>Back-Calibrated Sensitivities</u>

Thorium(Th) (cps/ppm):
Potassium(K) (cps/%):
Uranium(U) (cps/ppm):
Total Count(Tc) (cps/dose rate):

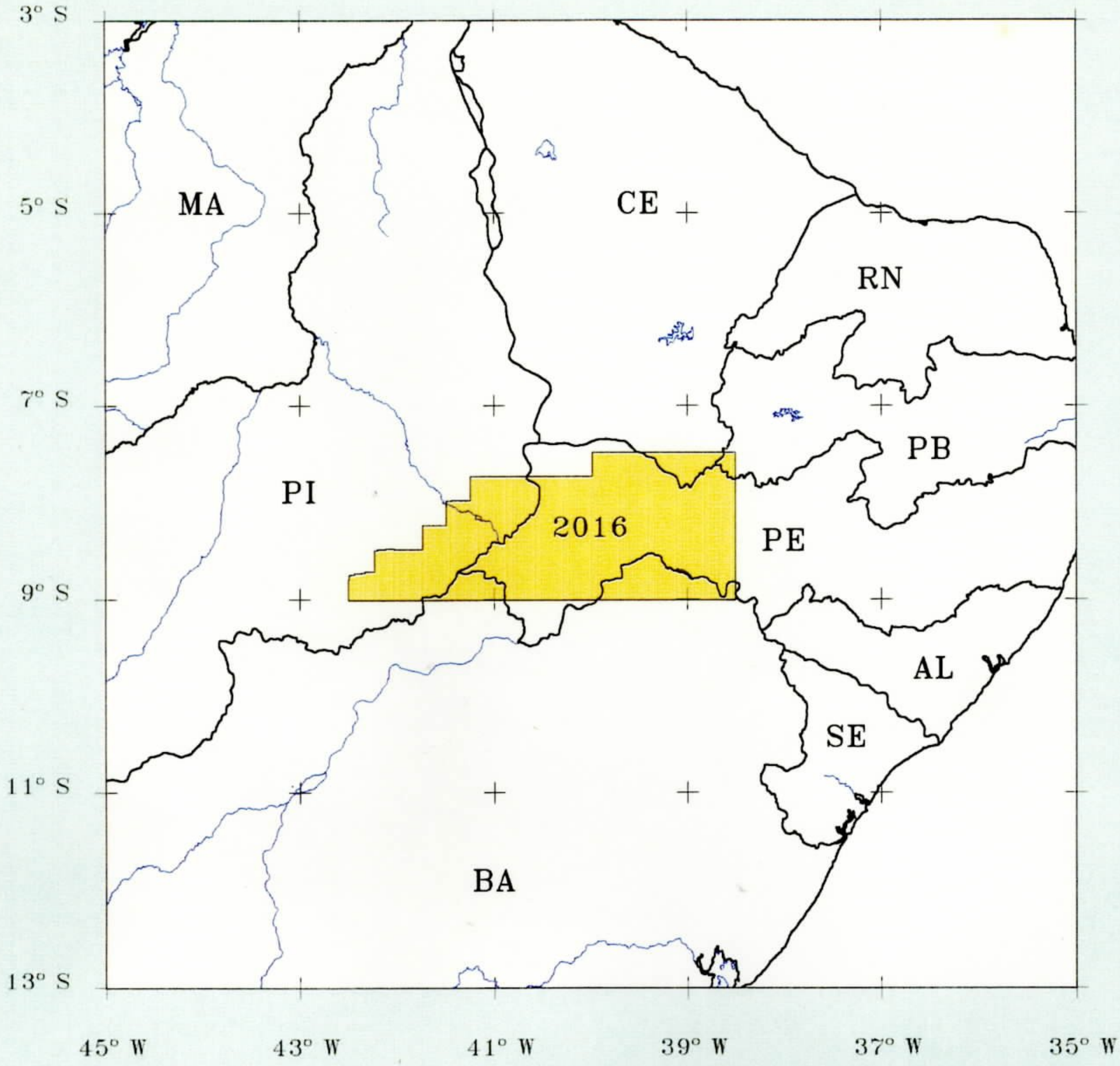
<u>Window Sizes</u>

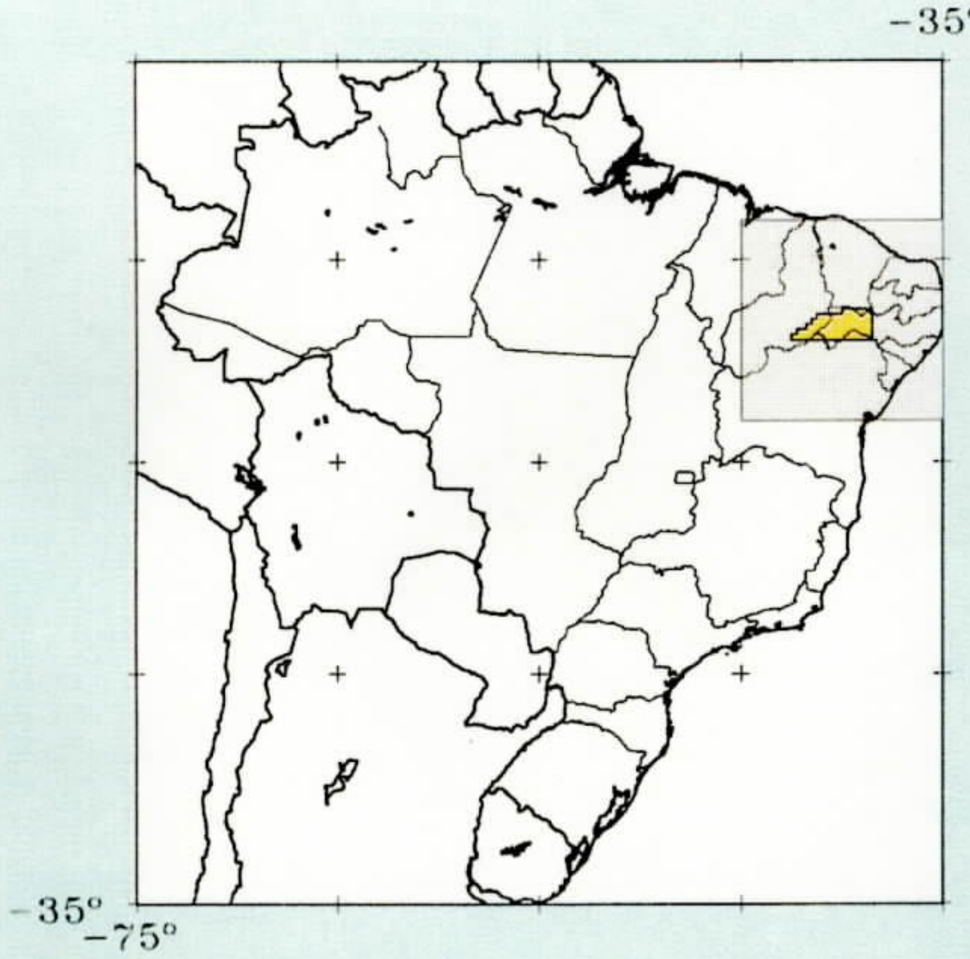
Thorium(Th) (MeV): ***Uranium(U) (MeV):***
Potassium(K) (MeV): ***Total Count(Tc) (MeV):***

<u>Stripping Ratios</u>

Alpha: ***Beta:***
Gamma:

Comments: Survey not included in BARMP. Data only available for U, Th, and Tc as stacked profiles maps.





Parnamirim

#2016

SAMMP # *CPRM #* **2016**

Project	**Parnamirim**
Client:	**Comissão Nacional de Energia Nuclear-CNEN**
Contractor:	**LASA**
Survey Completion Year:	**1975**

Number of Sub-Areas:	1
Total Area (km²):	55 000
Line km:	30 538
Flight Direction:	N-S
Line Spacing (km):	2
Tie Line Spacing (km):	20
Flight Altitude (mtc) (m):	135
Gamma-Spectrometer:	Exploranium DIGRS-3001
Crystal Volume (in³):	1017.87
Type of Aircraft:	Islander

Back-Calibrated Sensitivities

Thorium(Th) (cps/ppm):	1.78
Potassium(K) (cps/%):	30.0
Uranium(U) (cps/ppm):	16.0
Total Count(Tc) (cps/dose rate):	69.0

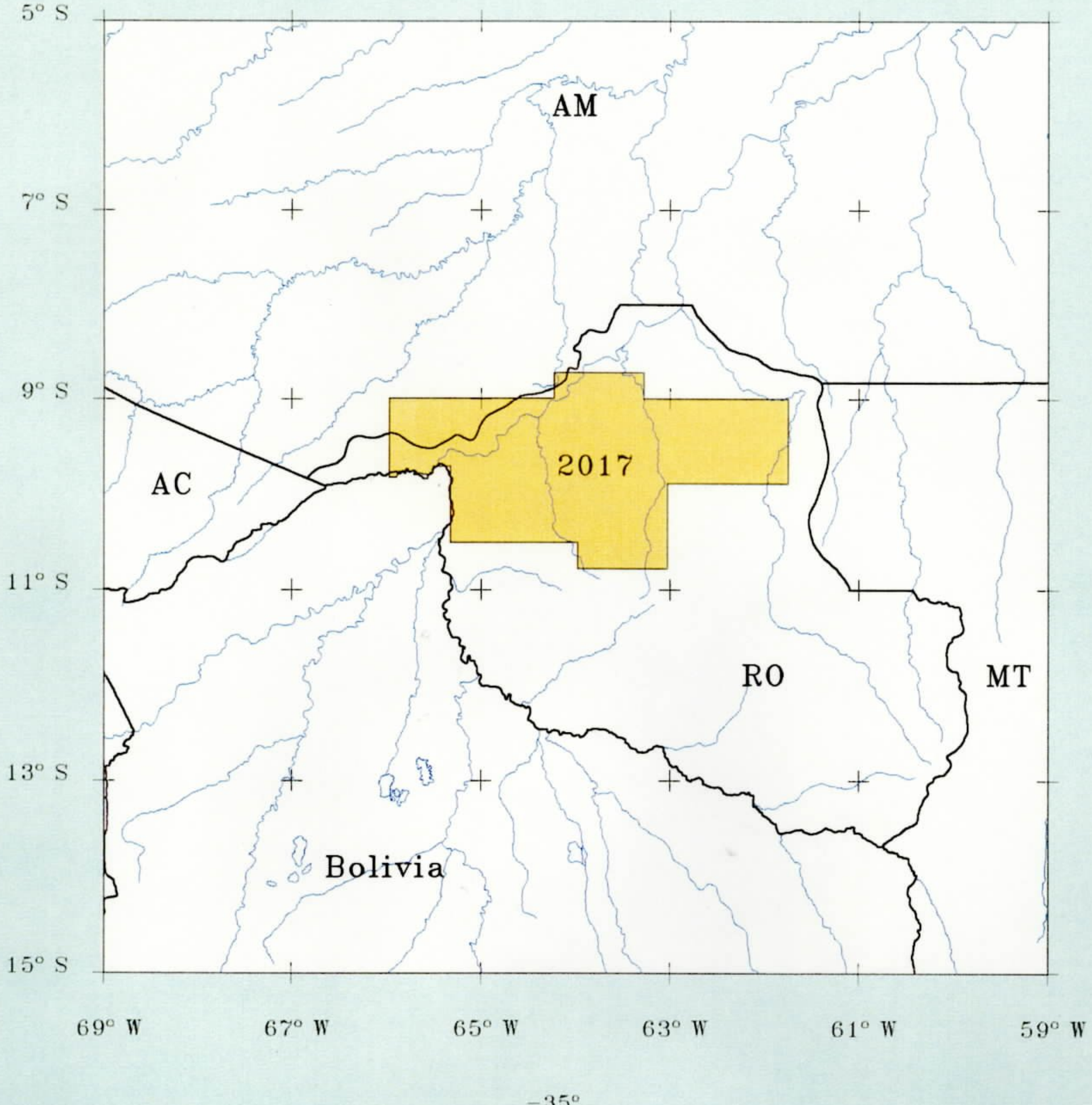
Window Sizes

Thorium(Th) (MeV):	***Uranium(U) (MeV):***
Potassium(K) (MeV):	***Total Count(Tc) (MeV):***

Stripping Ratios

Alpha:	***Beta:***
Gamma:	

Comments: -



Rio Madeira

#2017

SAMMP #	***CPRM #*** **2017**

Project	**Rio Madeira**
Client :	**Comissão Nacional de Energia Nuclear-CNEN**
Contractor:	**LASA**
Survey Completion Year:	**1974**

Number of Sub-Areas:	1
Total Area (km²):	112 000
Line km:	19 200
Flight Direction:	N-S
Line Spacing (km):	4
Tie Line Spacing (km):	40
Flight Altitude (mtc) (m):	135
Gamma-Spectrometer:	Exploranium DIGRS-3001
Crystal Volume (in³):	1017.87
Type of Aircraft:	Islander

Back-Calibrated Sensitivities

Thorium(Th) (cps/ppm):	1.78
Potassium(K) (cps/%):	30.0
Uranium(U) (cps/ppm):	15.0
Total Count(Tc) (cps/dose rate):	20.0

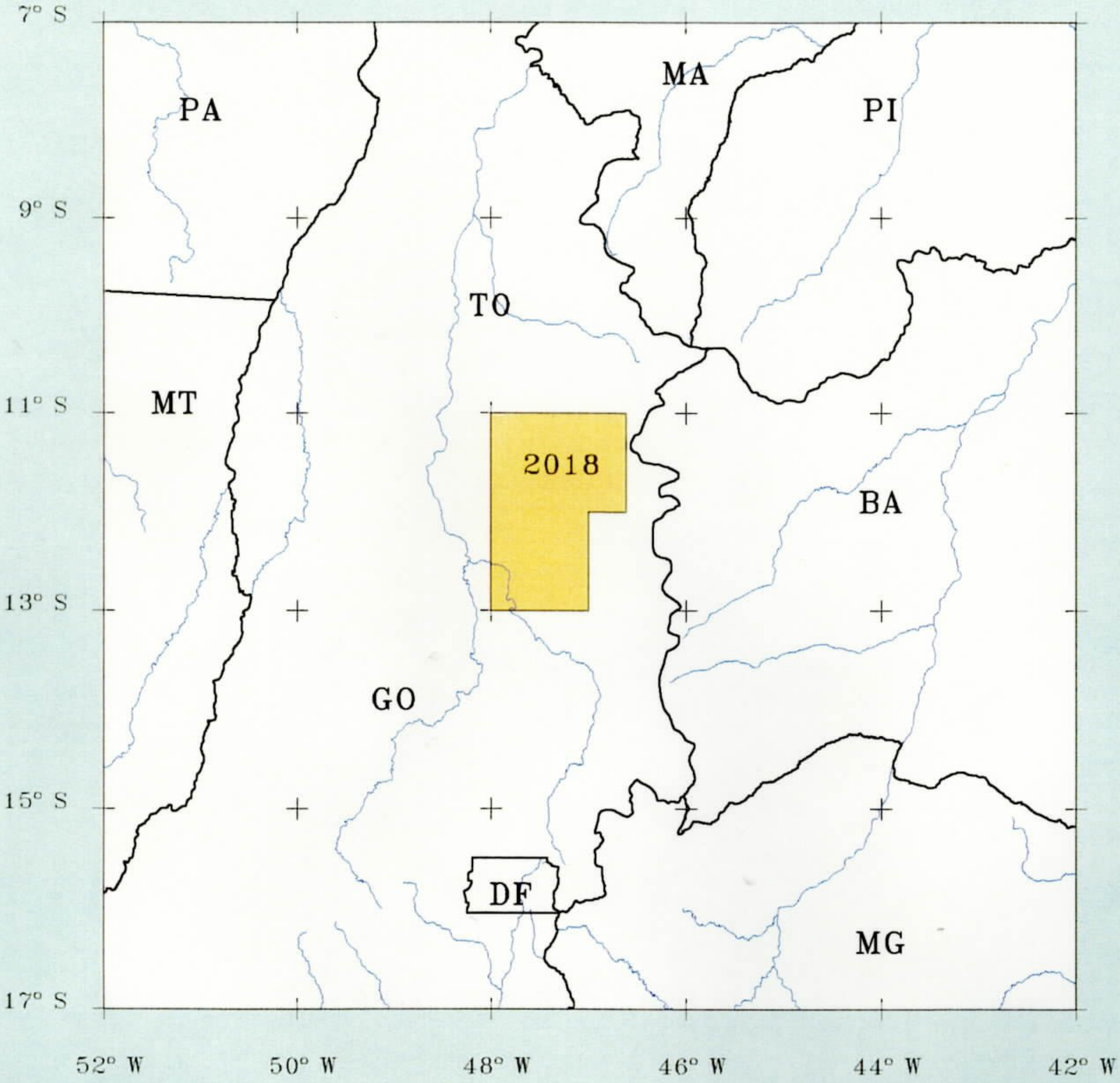
Window Sizes

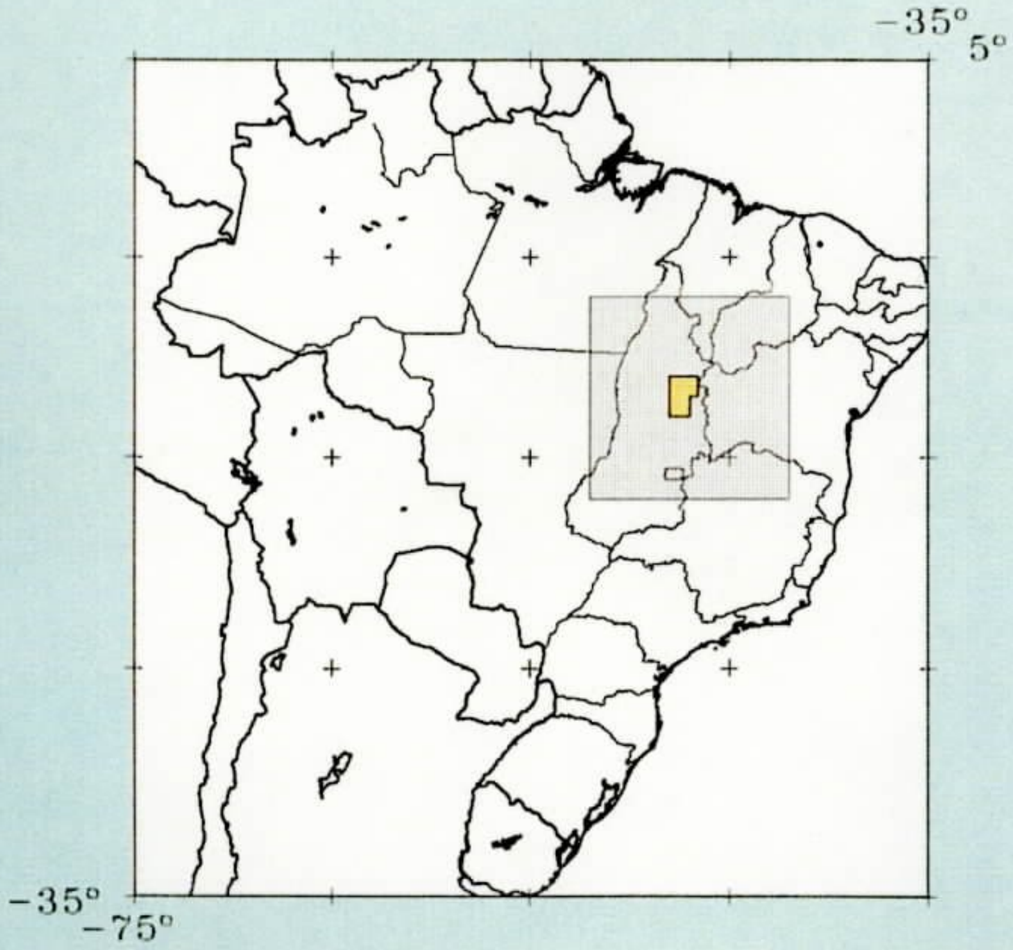
Thorium(Th) (MeV):	***Uranium(U) (MeV):*** 1.66 - 1.86
Potassium(K) (MeV):	***Total Count(Tc) (MeV):***

Stripping Ratios

Alpha: 0.361	***Beta:*** 0.484
Gamma: 0.753	

Comments:





Dianopolis

#2018

SAMMP #	**4121**	***CPRM #***	**2018**

Project	**Dianopólis**
Client:	**Empresas Nucleares Brasileiras S.A.-NUCLEBRÁS**
Contractor:	**LASA**
Survey Completion Year:	**1975**

Number of Sub-Areas:	2
Total Area (km²):	24 500
Line km:	16 367
Flight Direction:	N-S
Line Spacing (km):	2
Tie Line Spacing (km):	20
Flight Altitude (mtc) (m):	150
Gamma-Spectrometer:	Exploranium DIGRS-3001
Crystal Volume (in³):	1017.87
Type of Aircraft:	Islander

Back-Calibrated Sensitivities

Thorium(Th) (cps/ppm): 1.78
Potassium(K) (cps/%): 30.0
Uranium(U) (cps/ppm): 15.0
Total Count(Tc) (cps/dose rate): 20.0

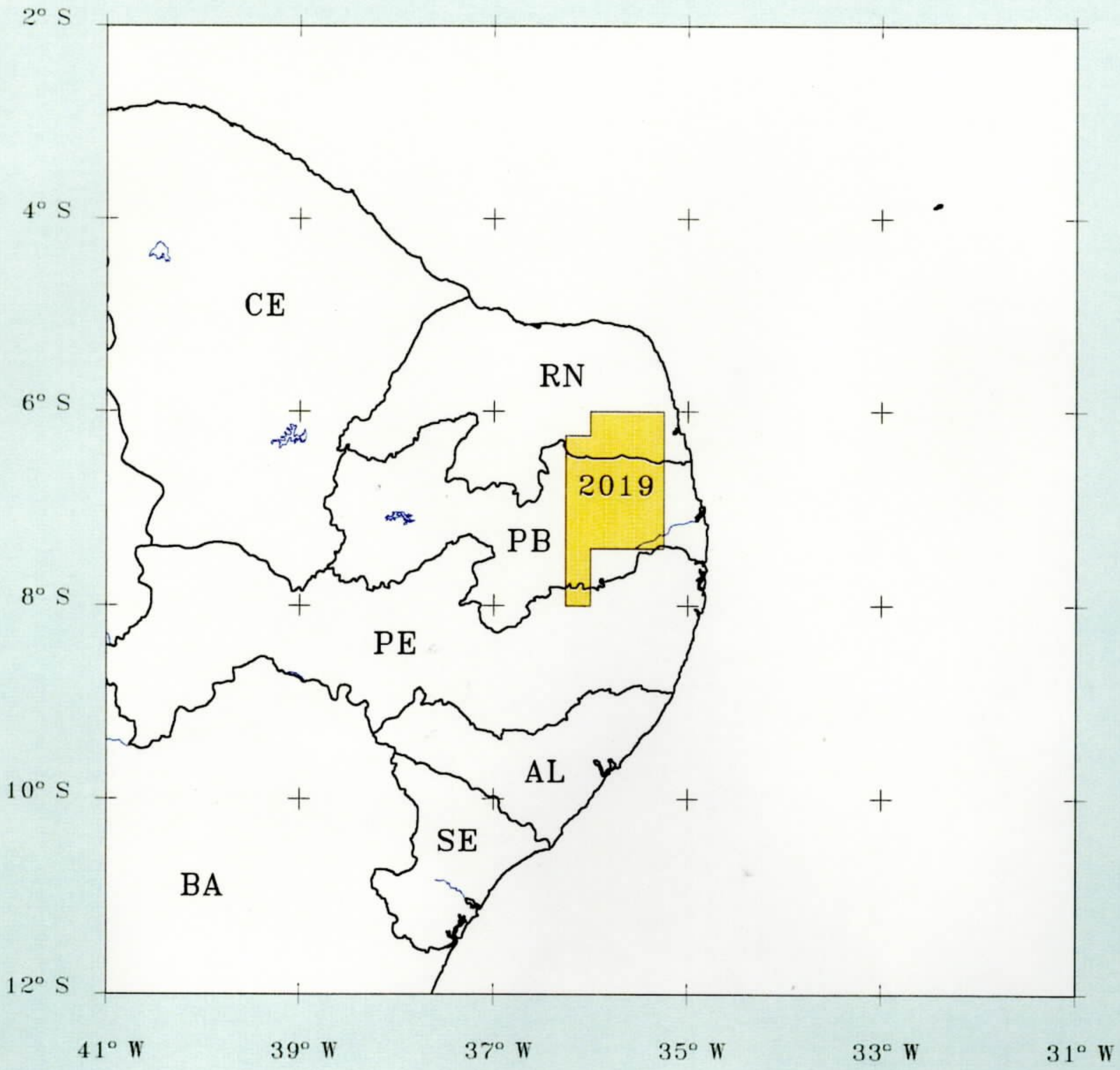
Window Sizes

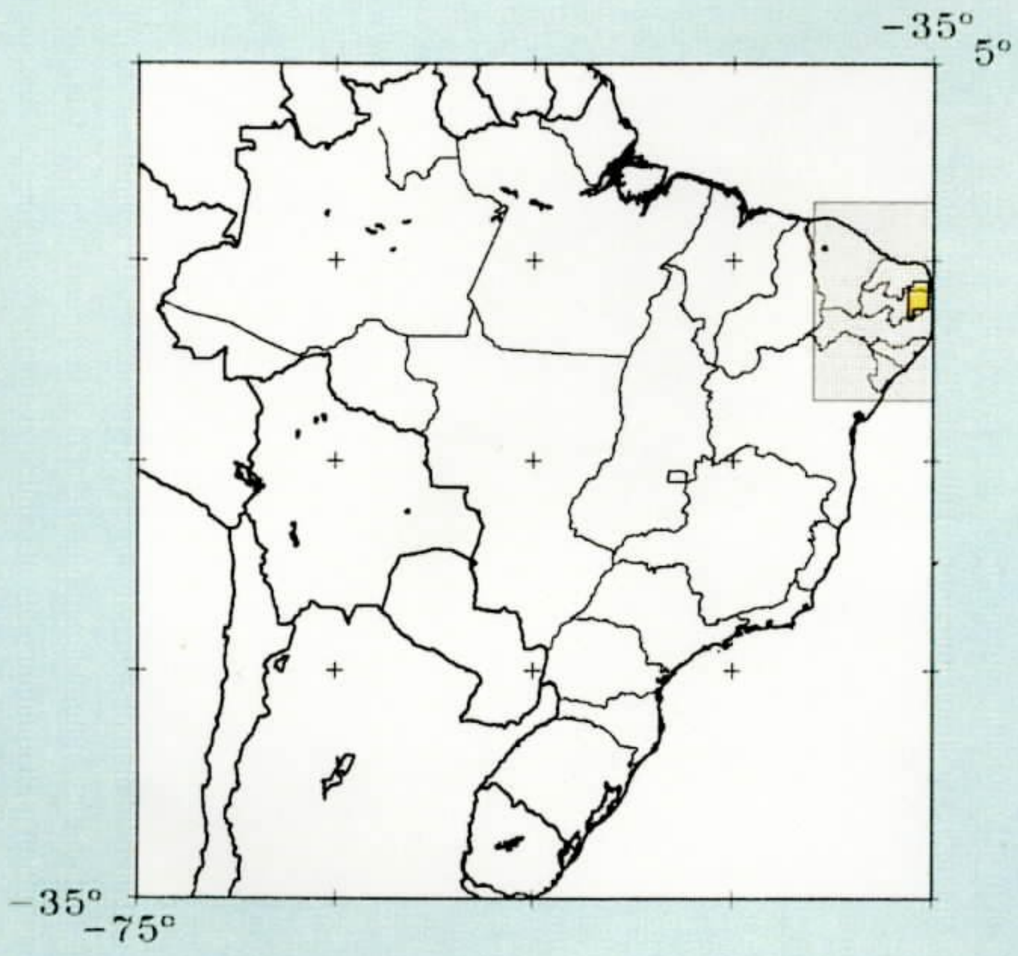
Thorium(Th) (MeV): ***Uranium(U) (MeV):***
Potassium(K) (MeV): ***Total Count(Tc) (MeV):***

Stripping Ratios

Alpha: ***Beta:***
Gamma:

Comments: Data available for U and Th channels only.





Esperanca

#2019

100

SAMMP #	**4132**	***CPRM #***	**2019**

Project	**Esperança**
Client:	**Empresas Nucleares Brasileiras S.A.-NUCLEBRÁS**
Contractor:	**LASA**
Survey Completion Year:	**1976**

Number of Sub-Areas:	1
Total Area (km²):	19 000
Line km:	19 170
Flight Direction:	N-S
Line Spacing (km):	1
Tie Line Spacing (km):	20
Flight Altitude (mtc) (m):	150
Gamma-Spectrometer:	Exploranium DIGRS-3001
Crystal Volume (in³):	1017.87
Type of Aircraft:	Islander

Back-Calibrated Sensitivities

Thorium(Th) (cps/ppm):	1.78
Potassium(K) (cps/%):	30.0
Uranium(U) (cps/ppm):	15.0
Total Count(Tc) (cps/dose rate):	20.0

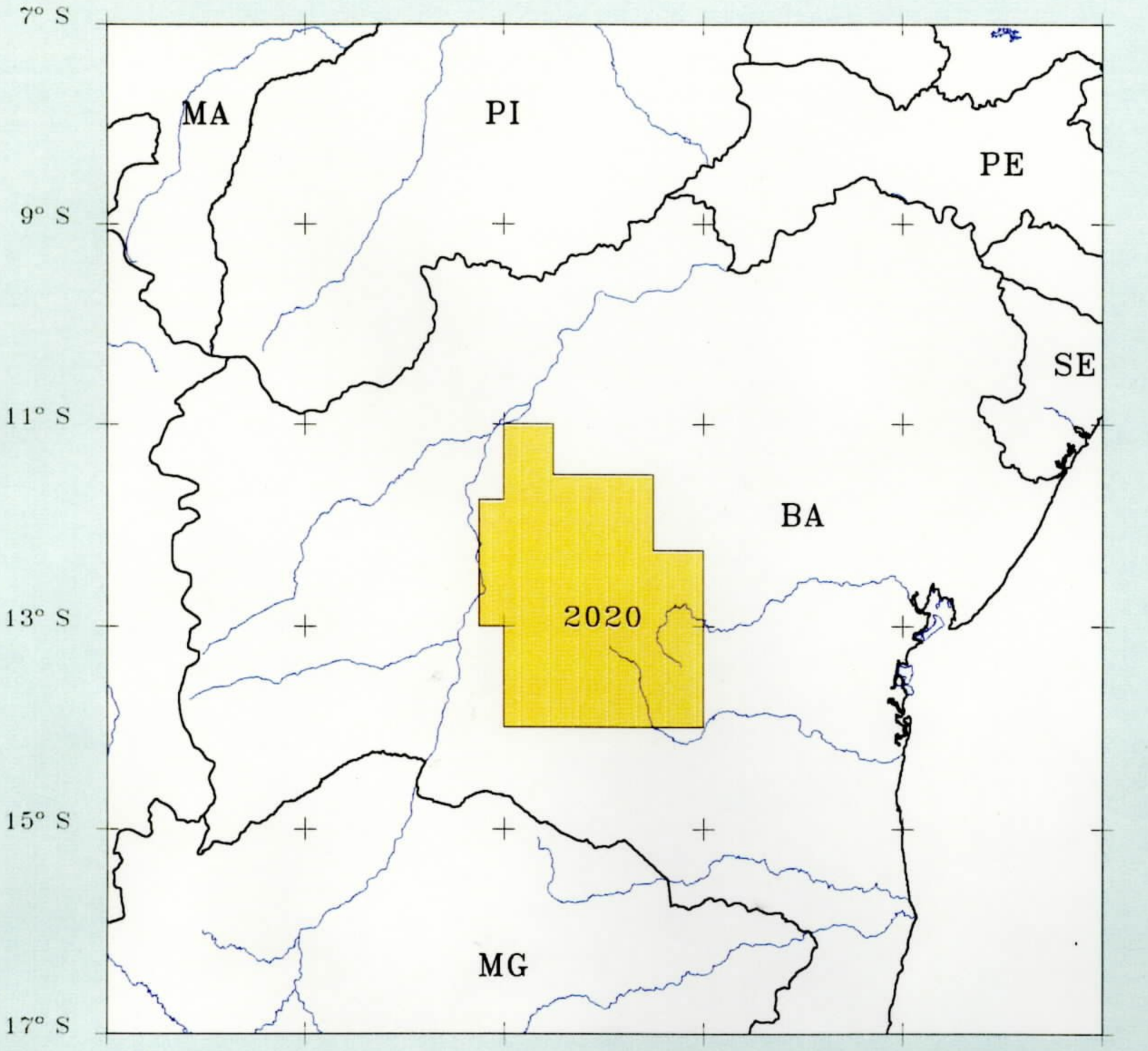
Window Sizes

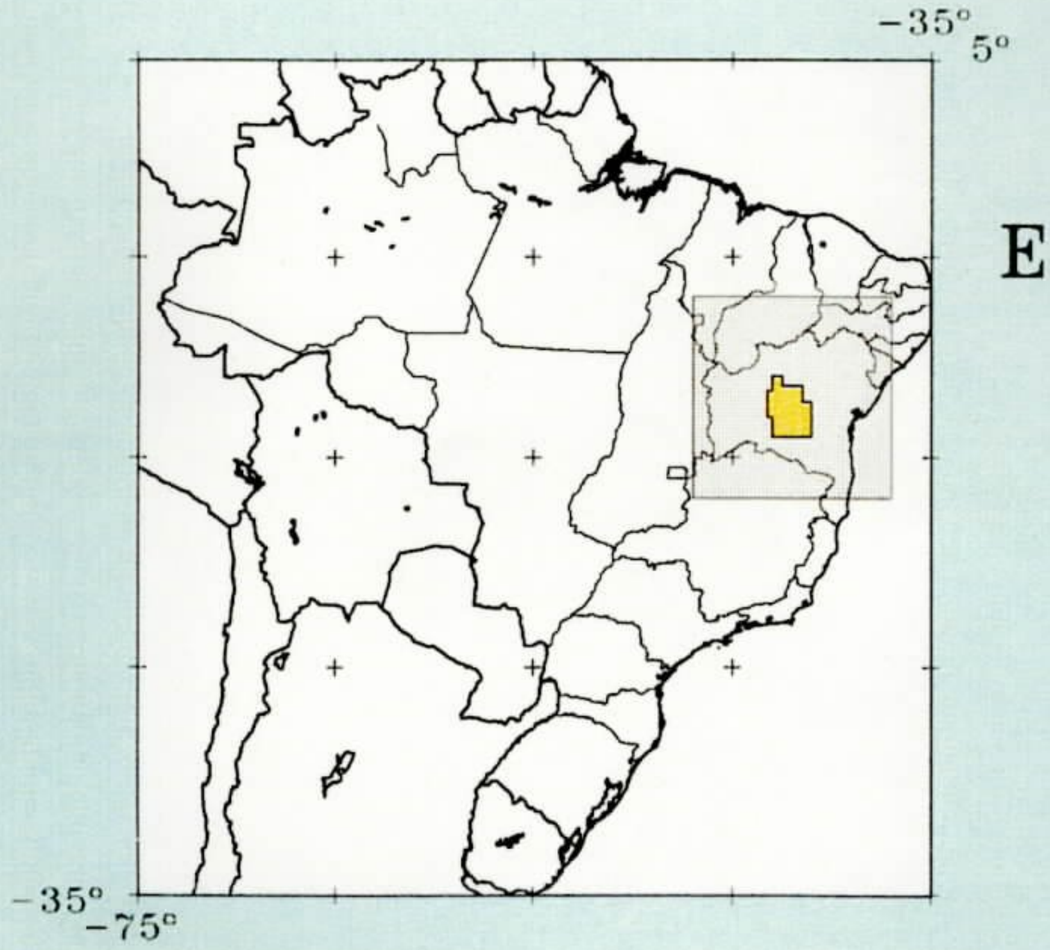
Thorium(Th) (MeV):	***Uranium(U) (MeV):***
Potassium(K) (MeV):	***Total Count(Tc) (MeV):***

Stripping Ratios

Alpha:	***Beta:***
Gamma:	

Comments: Data available for U and Th channels only.





Espinhaco Setentrional

#2020

102

SAMMP # **4119** *CPRM #* **2020**

Project **Espinhaço Setentrional**
Client: **Comissão Nacional de Energia Nuclear-CNEN/DNPM**
Contractor: **GEOFOTO**
Survey Completion Year: **1975**

Number of Sub-Areas: 1
Total Area (km²): 64 000
Line km: 18 354
Flight Direction: E-W
Line Spacing (km): 4
Tie Line Spacing (km): 20
Flight Altitude (mtc) (m): 150
Gamma-Spectrometer: Exploranium DIGRS-3001
Crystal Volume (in³): 1017.87
Type of Aircraft: Islander

Back-Calibrated Sensitivities

Thorium(Th) (cps/ppm): 5
Potassium(K) (cps/%): 245.0
Uranium(U) (cps/ppm): 40.0
Total Count(Tc) (cps/dose rate): 215.0

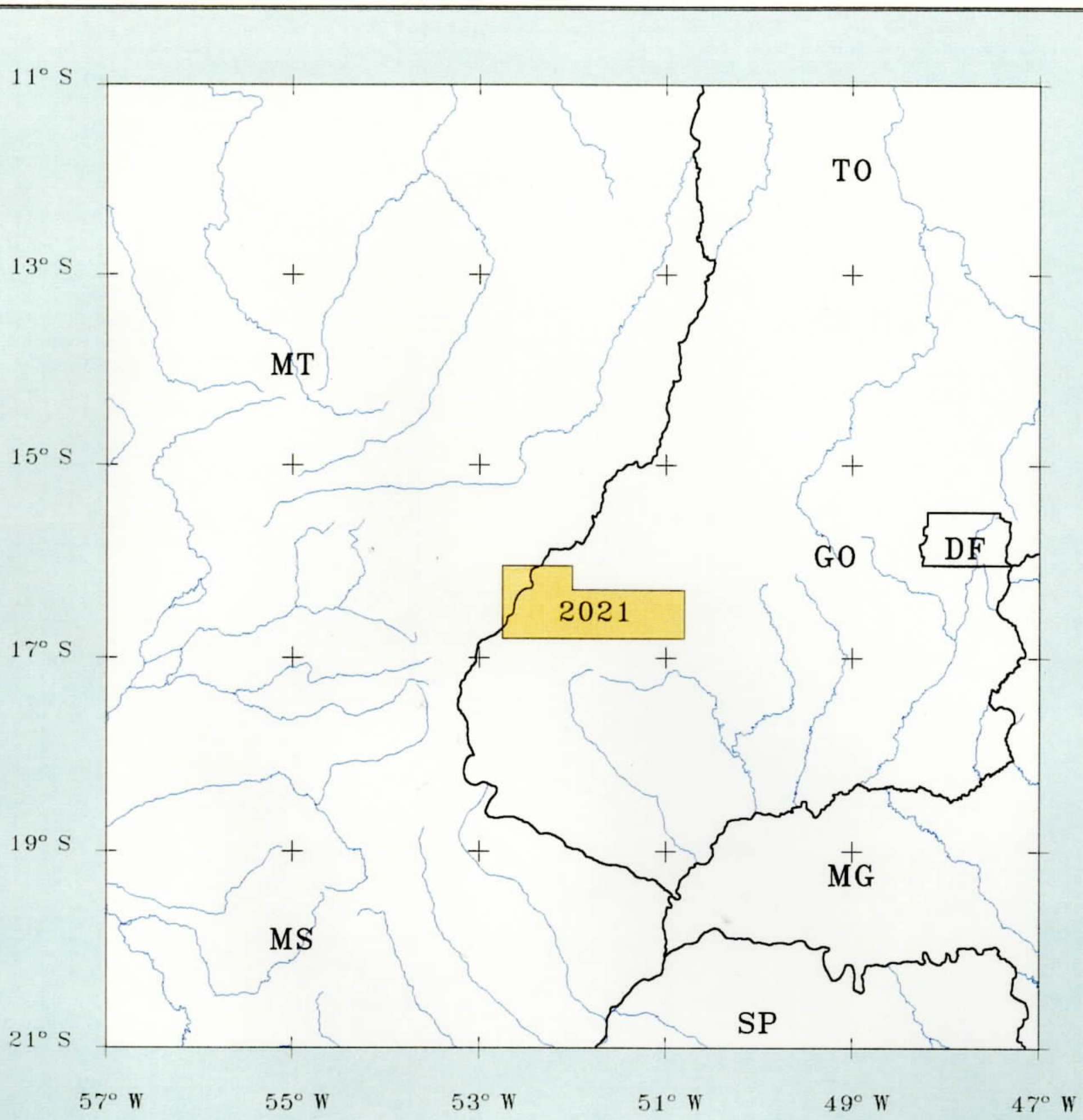
Window Sizes

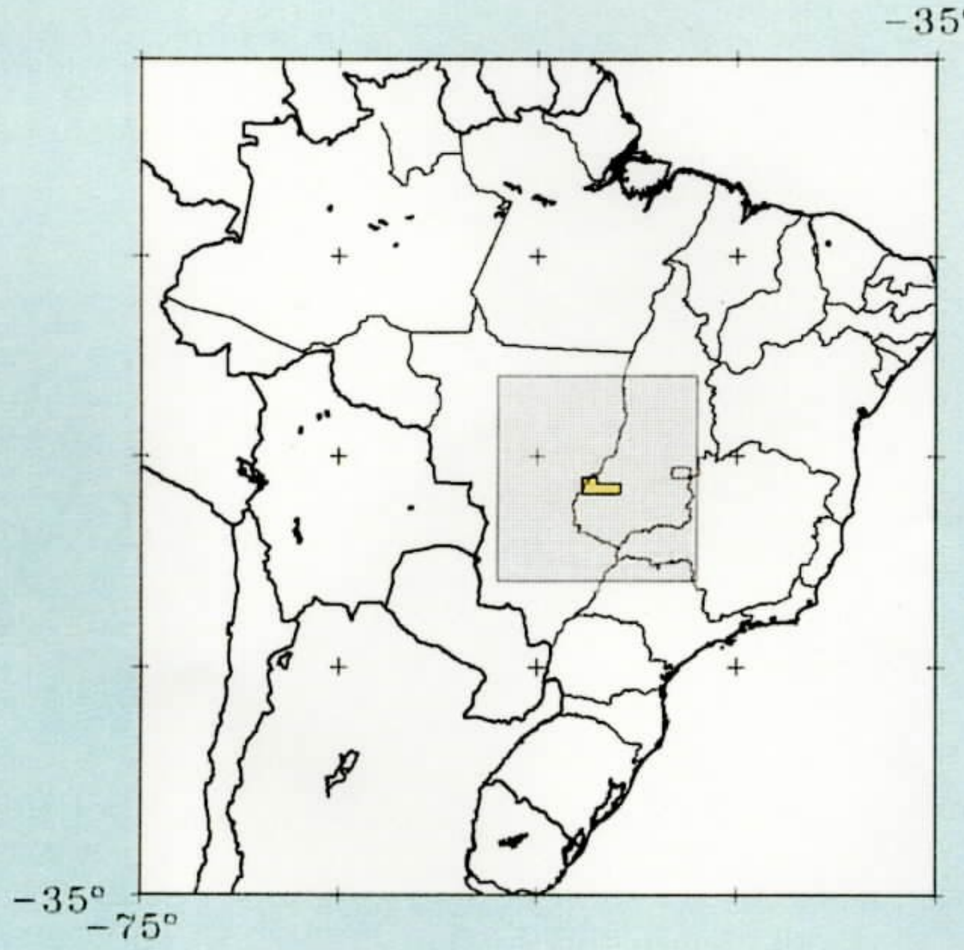
Thorium(Th) (MeV): *Uranium(U) (MeV):*
Potassium(K) (MeV): *Total Count(Tc) (MeV):*

Stripping Ratios

Alpha: *Beta:*
Gamma:

Comments: A base noise level of 11 counts was removed from the thorium data before the sensitivity was applied.





Amorinopolis

#2021

104

SAMMP # *CPRM #* **2021**

Project	**Amorinópolis**
Client:	**Empresas Nucleares Brasileiras S.A.-NUCLEBRÁS**
Contractor:	**LASA**
Survey Completion Year:	**1976**

Number of Sub-Areas:	2
Total Area (km^2):	13 600
Line km:	27 012
Flight Direction:	E-W
Line Spacing (km):	0.5
Tie Line Spacing (km):	unknown
Flight Altitude (mtc) (m):	150
Gamma-Spectrometer:	Exploranium DIGRS-3001
Crystal Volume (in^3):	1017.87
Type of Aircraft:	Islander

Back-Calibrated Sensitivities

Thorium(Th) (cps/ppm):
Potassium(K) (cps/%):
Uranium(U) (cps/ppm):
Total Count(Tc) (cps/dose rate):

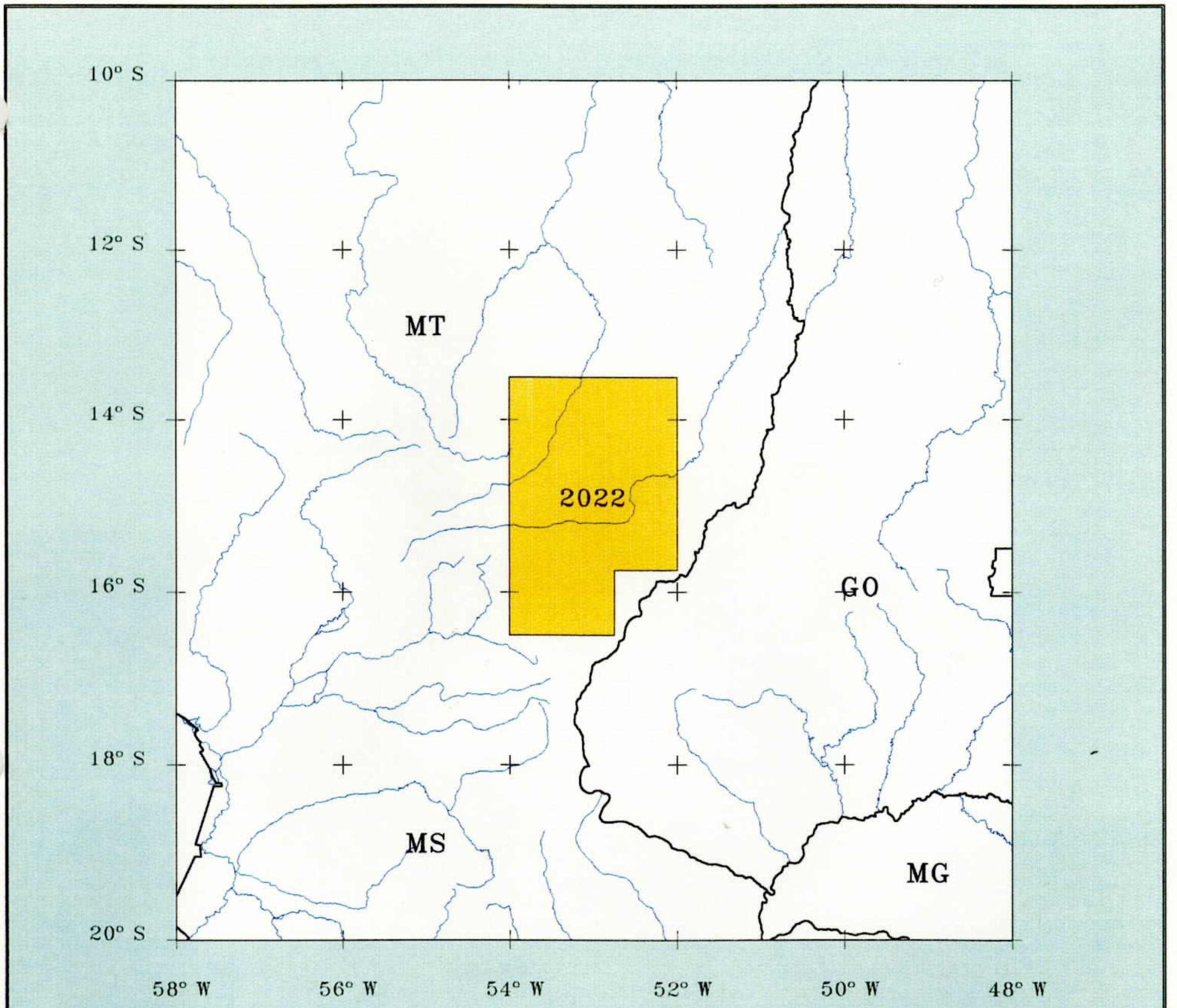
Window Sizes

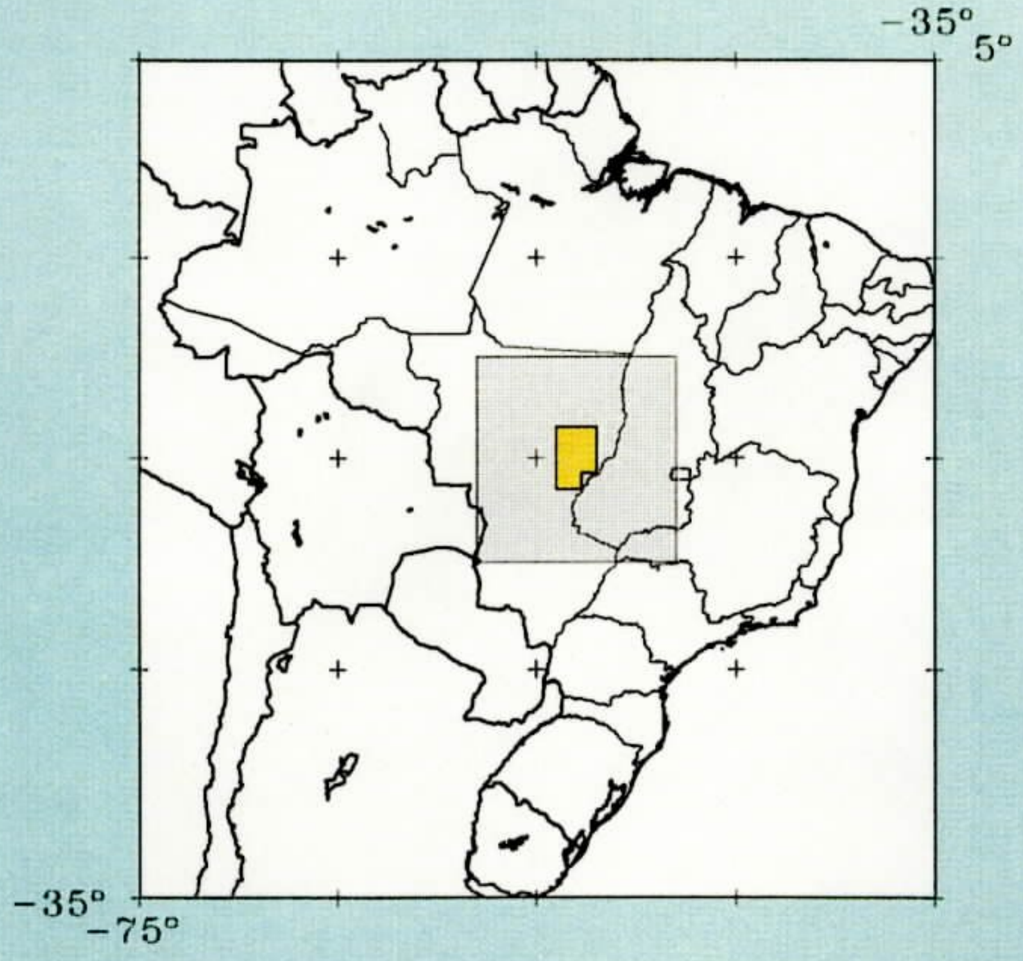
Thorium(Th) (MeV): 2.42 - 2.82	***Uranium(U) (MeV):*** 1.68 - 1.88
Potassium(K) (MeV): 1.36 - 1.56	***Total Count(Tc) (MeV):*** 0.90 - 2.82

Stripping Ratios

Alpha: 0.365	***Beta:*** 0.50
Gamma: 0.77	

Comments: Survey not included in BARMP. Data only available for U, Th and Tc as stacked profile maps.





Barreiro

#2022

10

SAMMP #	**4102**	***CPRM #***	**2022**

Project	**Barreiro**
Client:	**Empresas Nucleares Brasileiras S. A.-NUCLEBRÁS**
Contractor:	**ENCAL**
Survey Completion Year:	**1976**

Number of Sub-Areas:	1
Total Area (km^2):	66 000
Line km:	74 458
Flight Direction:	E-W
Line Spacing (km):	1
Tie Line Spacing (km):	20
Flight Altitude (mtc) (m):	150
Gamma-Spectrometer:	Exploranium DIGRS-3001
Crystal Volume (in^3):	1017.87
Type of Aircraft:	Islander

Back-Calibrated Sensitivities

Thorium(Th) (cps/ppm):	1.4
Potassium(K) (cps/%):	20.0
Uranium(U) (cps/ppm):	8.0
Total Count(Tc) (cps/dose rate):	23.6

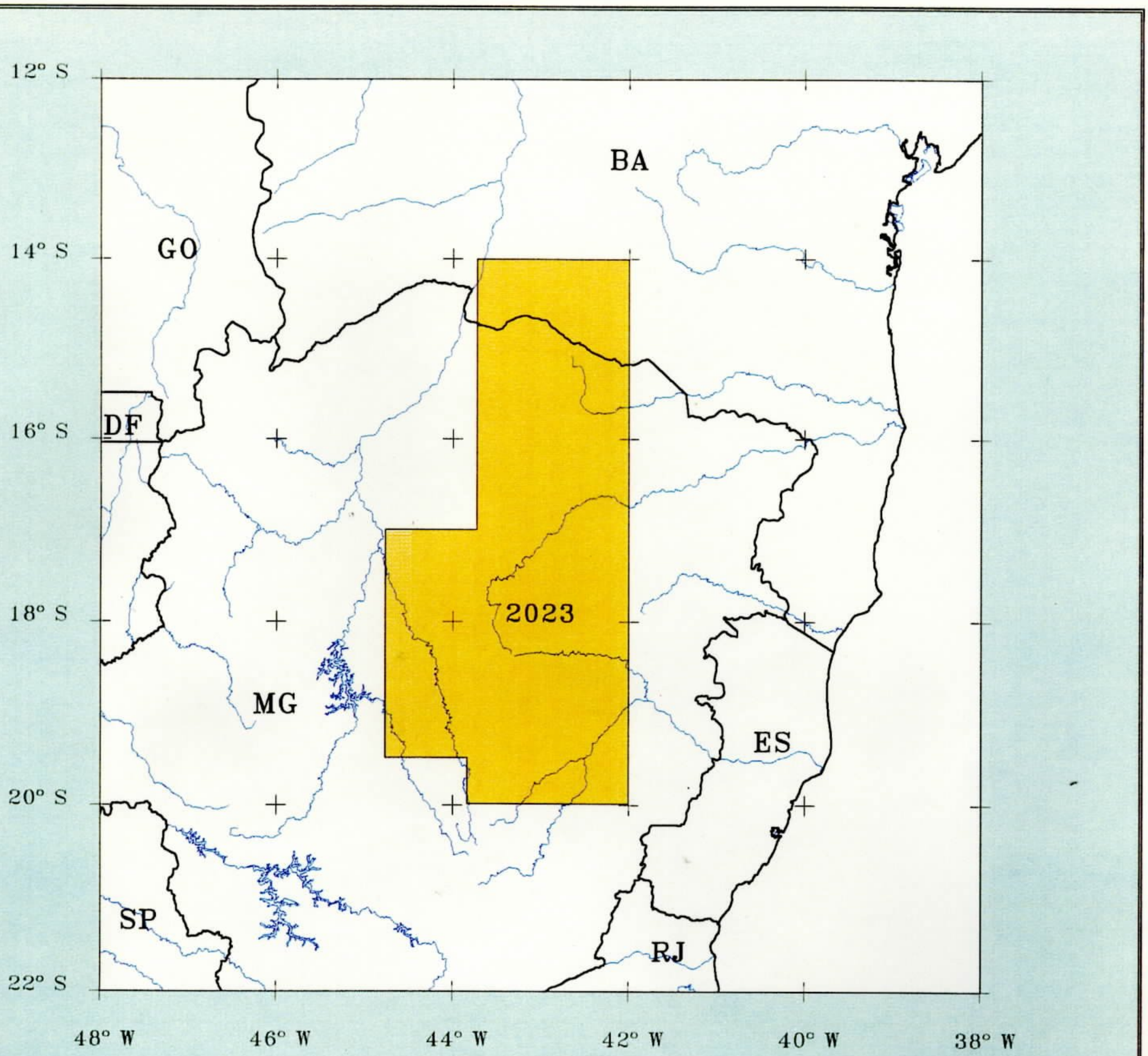
Window Sizes

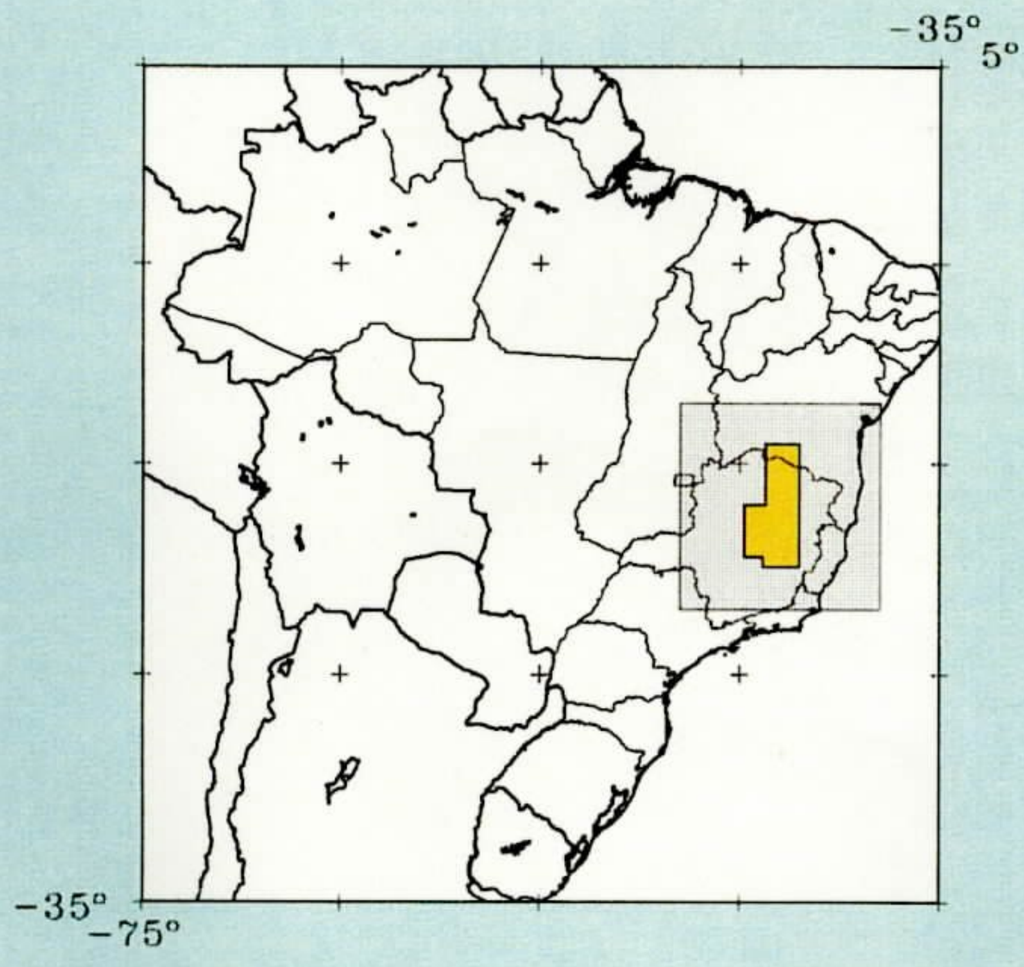
Thorium(Th) (MeV):	2.40 - 2.80	***Uranium(U) (MeV):***	1.66 - 1.86
Potassium(K) (MeV):	1.37 - 1.57	***Total Count(Tc) (MeV):***	0.40 - 3.0

Stripping Ratios

Alpha:	0.365	***Beta:***	0.485
Gamma:	0.752		

Comments: A base noise level in counts was removed from the data before the sensitivities were applied. Th-7, U-8, K-18.5 and Tc-15.4.





Diamantina

#2023

SAMMP #	***CPRM #*** **2023**
Project	**Diamantina**
Client :	**Empresas Nucleares Brasileiras S.A.-NUCLEBRÁS**
Contractor:	**GEOFOTO**
Survey Completion Year:	**1976**

Number of Sub-Areas:	1
Total Area (km^2):	145 000
Line km:	78 000
Flight Direction:	E-W
Line Spacing (km):	2
Tie Line Spacing (km):	20
Flight Altitude (mtc) (m):	150
Gamma-Spectrometer:	Exploranium DIGRS-3001
Crystal Volume (in^3):	1017.87
Type of Aircraft:	Islander DC-3

<u>Back-Calibrated Sensitivities</u>

Thorium(Th) (cps/ppm):
Potassium(K) (cps/%):
Uranium(U) (cps/ppm):
Total Count(Tc) (cps/dose rate):

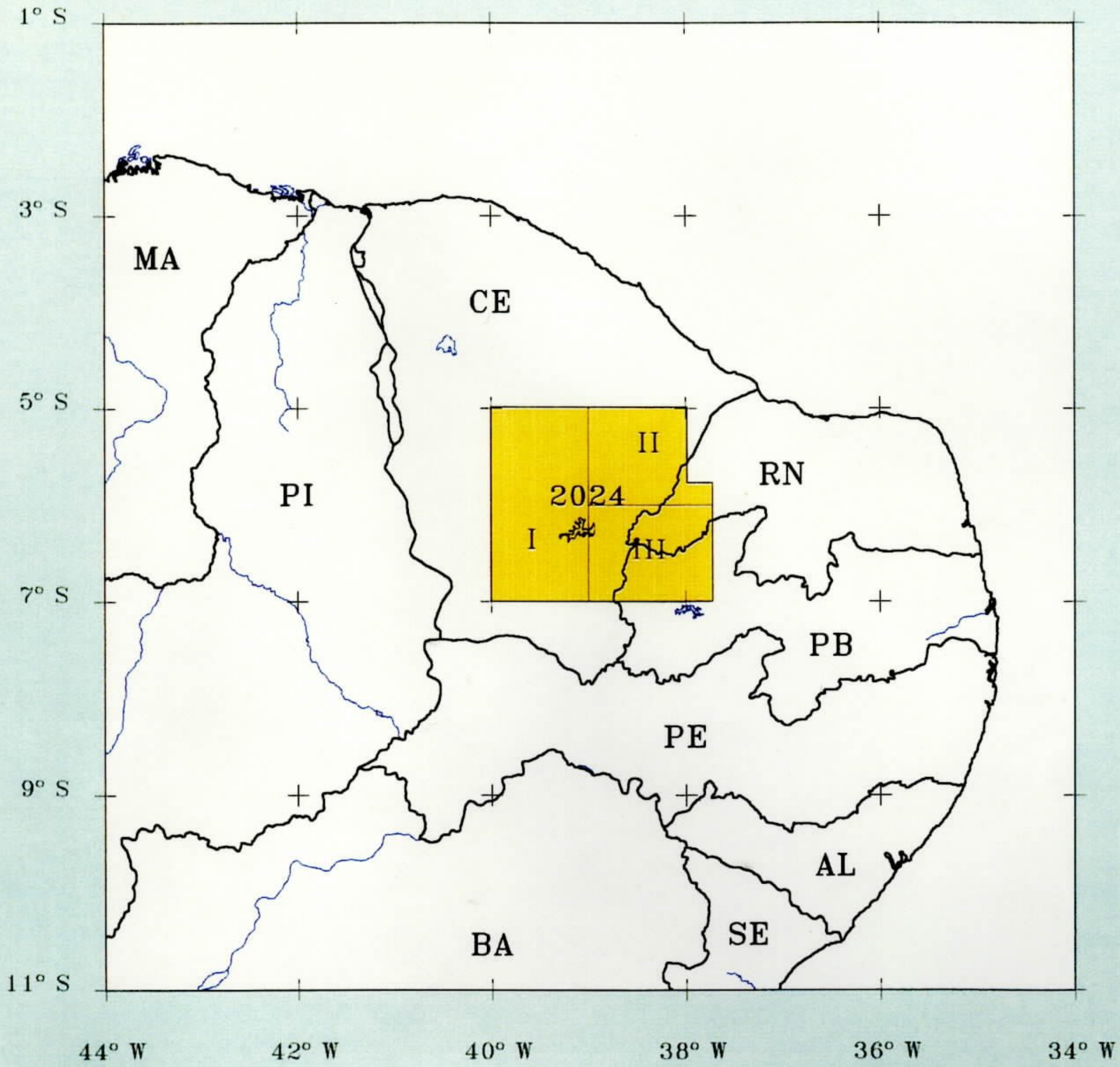
<u>Window Sizes</u>

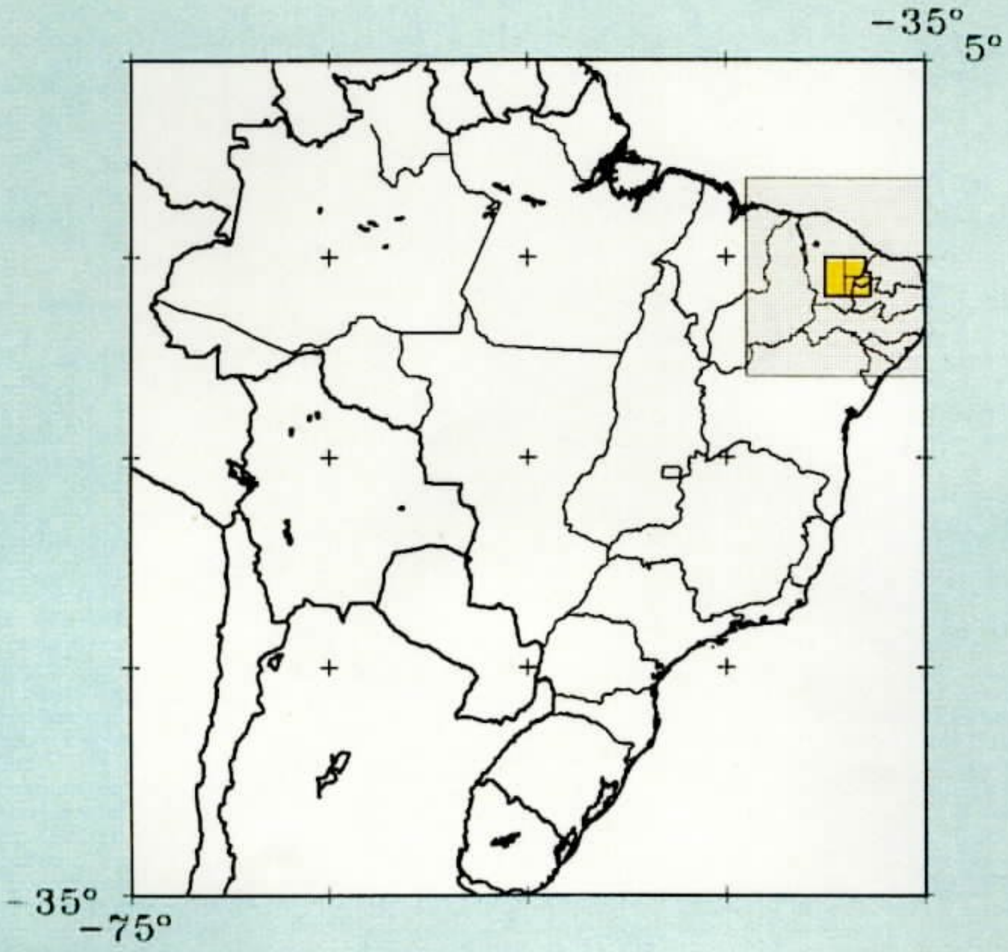
Thorium(Th) (MeV): 2.42 - 2.82	***Uranium(U) (MeV):*** 1.68 - 1.86
Potassium(K) (MeV): 1.36 - 1.56	***Total Count(Tc) (MeV):***

<u>Stripping Ratios</u>

Alpha: 0.36	***Beta:*** 0.47
Gamma: 0.73	

Comments:


1° S
3° S
5° S
7° S
9° S
11° S
44° W
42° W
40° W
38° W
36° W
34° W
MA
CE
PI
RN
PB
PE
AL
SE
BA
I
II
III
2024


-35°
5°
-35°
-75°

Iguatu

#2024

SAMMP # **4107** *CPRM #* **2024.01**

Project	**Iguatu**
Client:	**Empresas Nucleares Brasileiras S. A.-NUCLEBRÁS**
Contractor:	**ENCAL**
Survey Completion Year:	**1977**

Number of Sub-Areas:	1
Total Area (km²):	22 000
Line km:	25 000
Flight Direction:	N45W
Line Spacing (km):	1
Tie Line Spacing (km):	20
Flight Altitude (mtc) (m):	150
Gamma-Spectrometer:	Exploranium DIGRS-3001
Crystal Volume (in³):	1024
Type of Aircraft:	Islander

Back-Calibrated Sensitivities

Thorium(Th) (cps/ppm):	1.15
Potassium(K) (cps/%):	12.5
Uranium(U) (cps/ppm):	2.5
Total Count(Tc) (cps/dose rate):	23.0

Window Sizes

Thorium(Th) (MeV):	*Uranium(U) (MeV):*
Potassium(K) (MeV):	*Total Count(Tc) (MeV):*

Stripping Ratios

Alpha: 0.365	*Beta:* 0.484
Gamma: 0.752	

Comments: Area west of 39° west.

SAMMP # **4107** *CPRM #* **2024.02**

Project	**Iguatu**
Client:	**Empresas Nucleares Brasileiras S. A.-NUCLEBRÁS**
Contractor :	**ENCAL**
Survey Completion Year:	**1977**

Number of Sub-Areas:	2
Total Area (km²):	30 000
Line km:	30 000
Flight Direction:	N45W
Line Spacing (km):	1
Tie Line Spacing (km):	20
Flight Altitude (mtc) (m):	150
Gamma-Spectrometer:	Geometrics GR-800A
Crystal Volume (in³):	3072
Type of Aircraft:	Bandeirante

Back-Calibrated Sensitivities

Thorium(Th) (cps/ppm):	5.00
Potassium(K) (cps/%):	76.0
Uranium(U) (cps/ppm):	12.0
Total Count(Tc) (cps/dose rate):	205.0

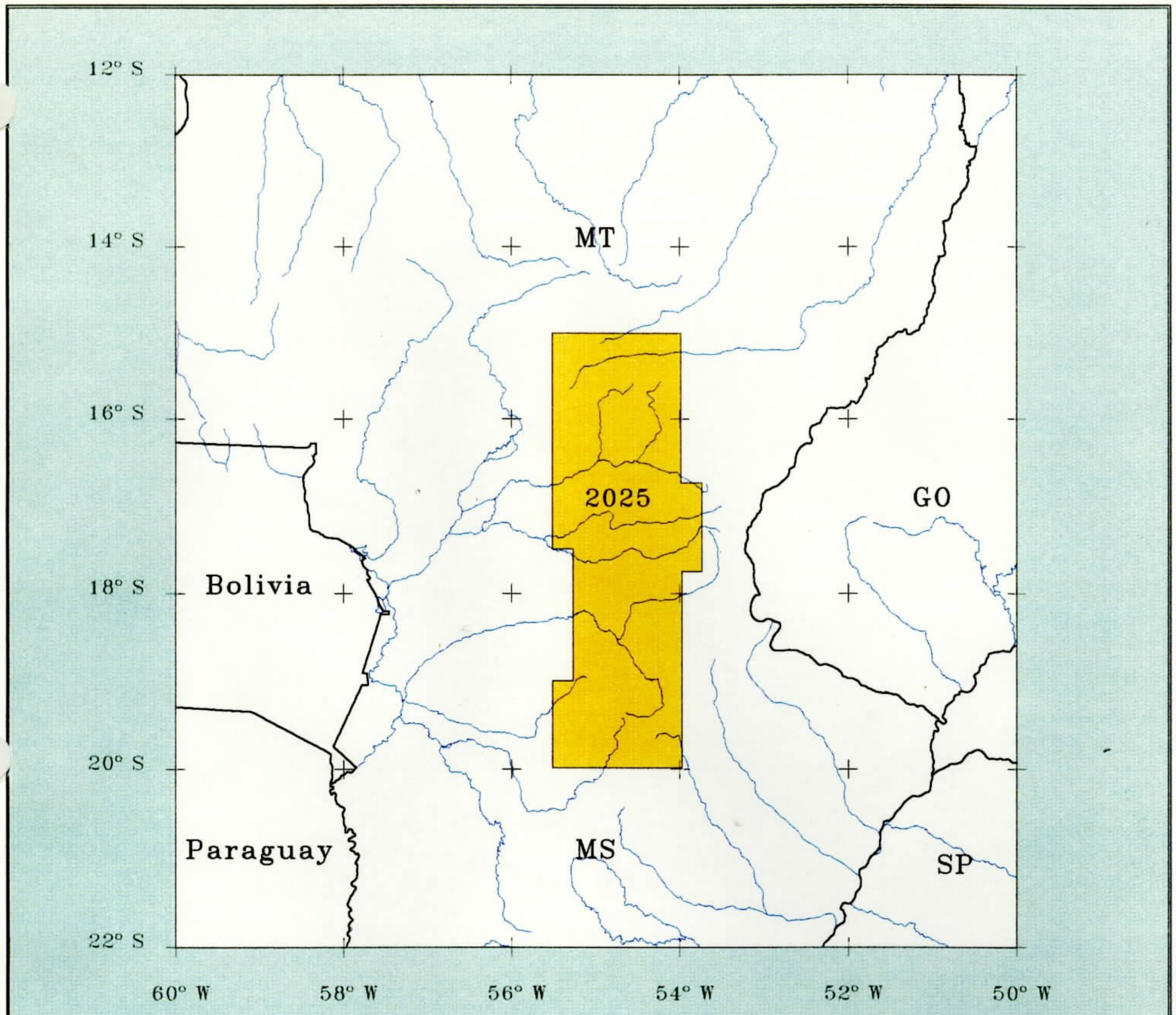
Window Sizes

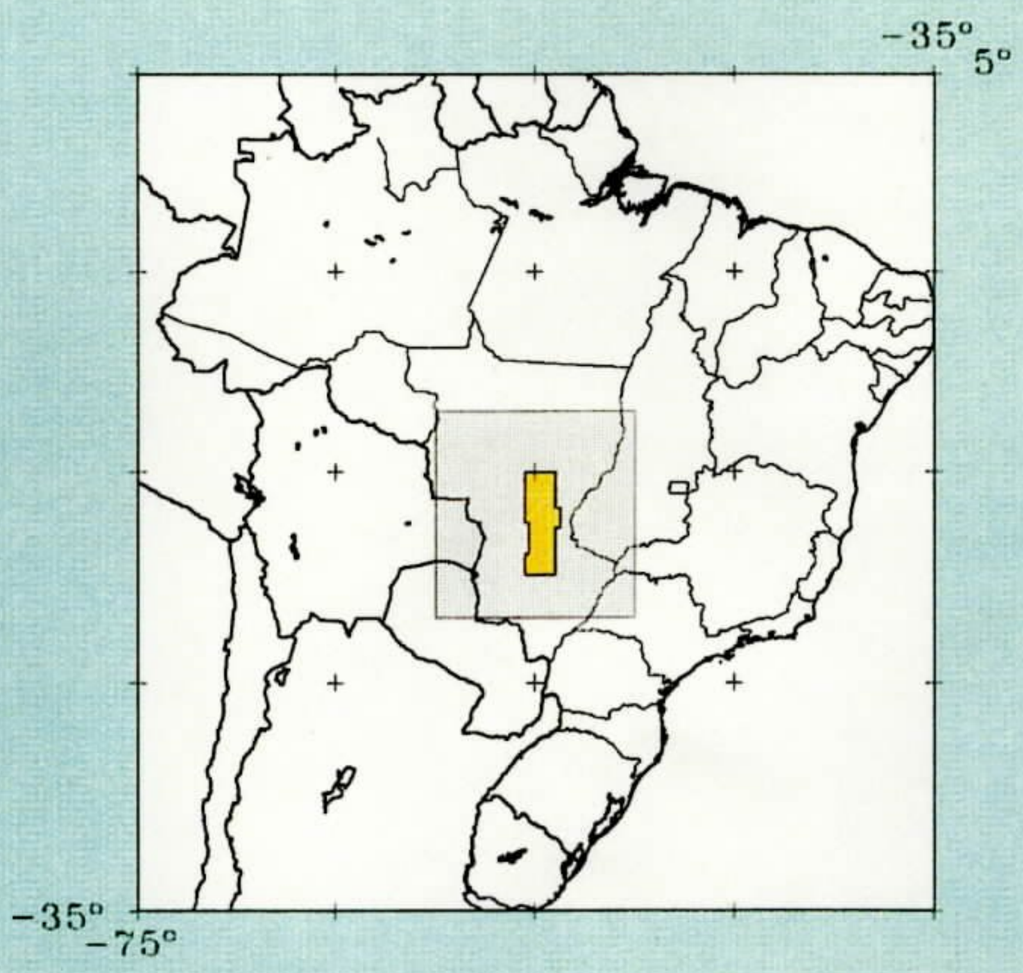
Thorium(Th) (MeV):	*Uranium(U) (MeV):*
Potassium(K) (MeV):	*Total Count(Tc) (MeV):*

Stripping Ratios

Alpha: 0.350	*Beta:* 0.334
Gamma: 0.564	

Comments: Area east of 39° west.





Rondonopolis

#2025

SAMMP # **4093** *CPRM #* **2025**

Project	**Rondonópolis**
Client:	**Empresas Nucleares Brasileiras S. A.-NUCLEBRÁS**
Contractor:	**LASA**
Survey Completion Year:	**1977**

Number of Sub-Areas:	2
Total Area (km²):	85 000
Line km:	91 380
Flight Direction:	E-W
Line Spacing (km):	1
Tie Line Spacing (km):	20
Flight Altitude (mtc) (m):	150
Gamma-Spectrometer:	Exploranium DIGRS-3001
Crystal Volume (in³):	1017.87
Type of Aircraft:	Islander

Back-Calibrated Sensitivities

Thorium(Th) (cps/ppm):	1.78
Potassium(K) (cps/%):	25.88
Uranium(U) (cps/ppm):	10.07
Total Count(Tc) (cps/dose rate):	51.79

Window Sizes

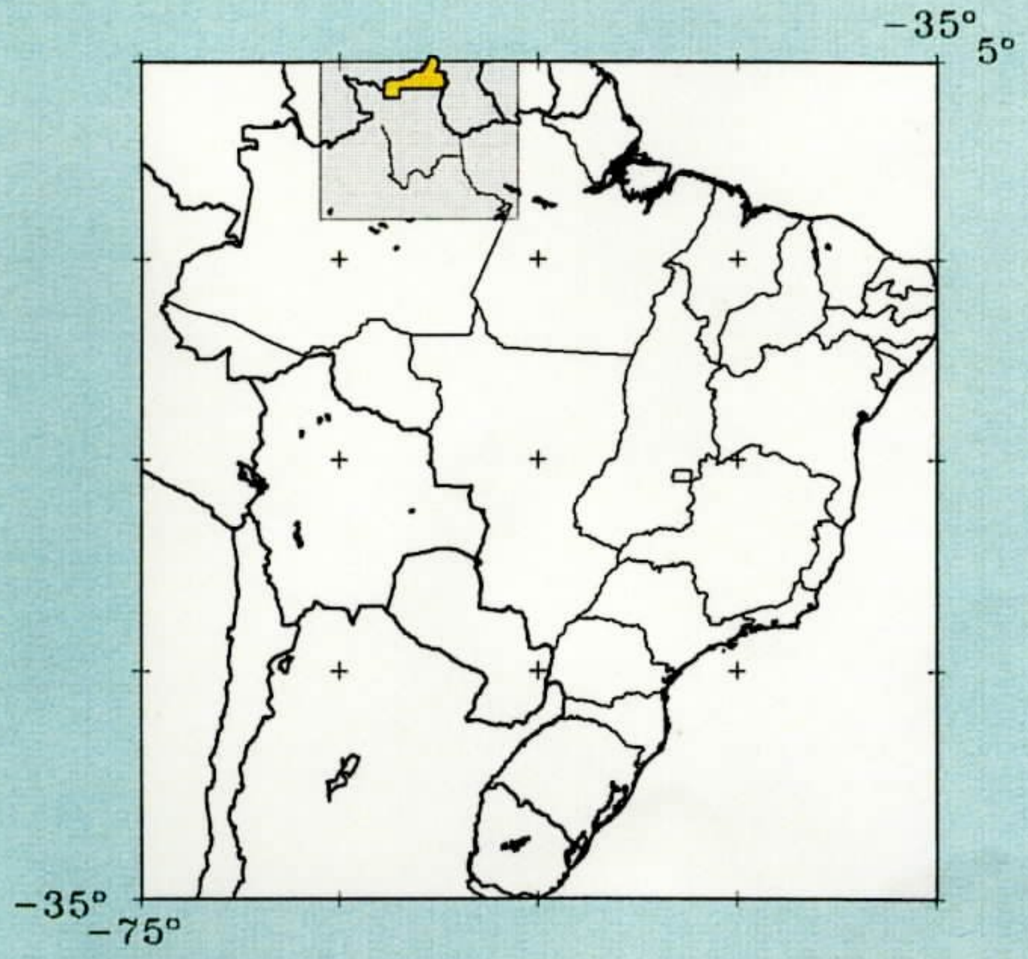
Thorium(Th) (MeV):	2.42 - 2.82	*Uranium(U) (MeV):*	1.68 - 1.88
Potassium(K) (MeV):	1.36 - 1.56	*Total Count(Tc) (MeV):*	0.90 - 2.82

Stripping Ratios

Alpha:	0.365	*Beta:*	0.50
Gamma:	0.77		

Comments: -


7° N
5° N
3° N
1° N
1° S
3° S
66° W
64° W
62° W
60° W
58° W
56° W
Venezuela
Guyana
2026
RR
PA
AM


-35°
5°
-35°
-75°

Surumu

#2026

SAMMP # **4091** *CPRM #* **2026**

Project **Surumu**
Client: **Empresas Nucleares Brasileiras S. A.-NUCLEBRÁS**
Contractor : **ENCAL**
Survey Completion Year: **1977**

Number of Sub-Areas: 1
Total Area (km²): 35 000
Line km: 40 000
Flight Direction: N-S
Line Spacing (km): 1
Tie Line Spacing (km): 20
Flight Altitude (mtc) (m): 150
Gamma-Spectrometer: Geometrics GR-800A
Crystal Volume (in³): 3072
Type of Aircraft: Bandeirante

Back-Calibrated Sensitivities

Thorium(Th) (cps/ppm): 4.2
Potassium(K) (cps/%): 75.23
Uranium(U) (cps/ppm): 8.42
Total Count(Tc) (cps/dose rate): 207.16

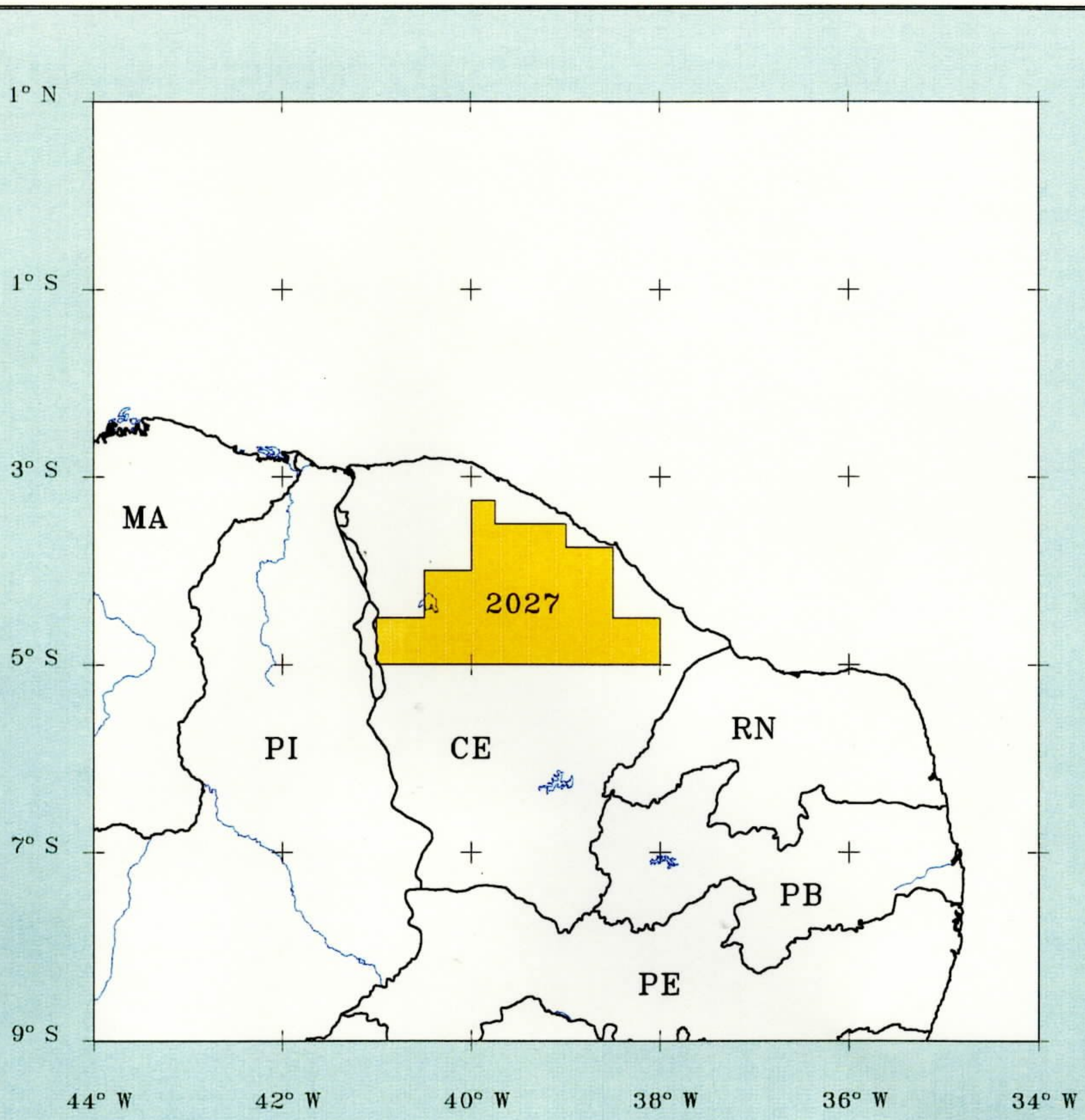
Window Sizes

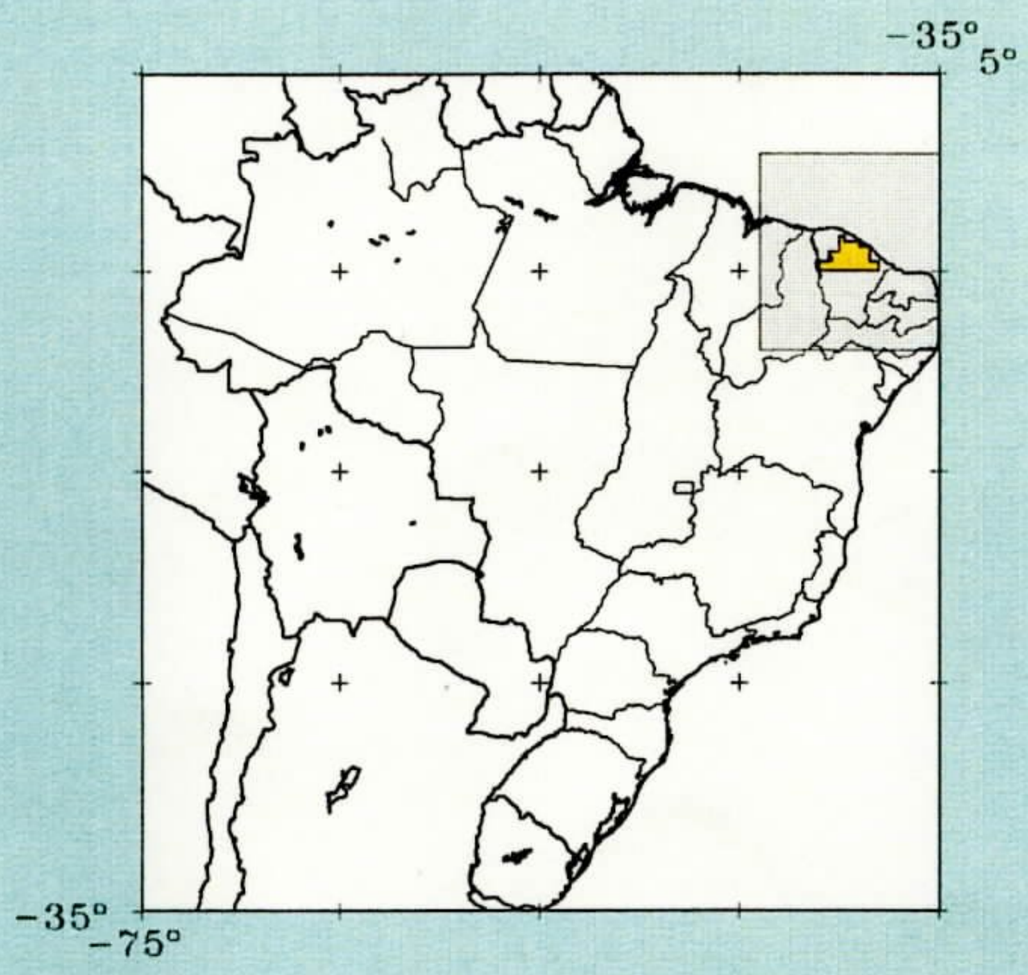
Thorium(Th) (MeV): *Uranium(U) (MeV):*
Potassium(K) (MeV): *Total Count(Tc) (MeV):*

Stripping Ratios

Alpha: *Beta:*
Gamma:

Comments: -





Itatira

#2027

SAMMP #	**4131**	***CPRM #***	**2027**

Project	**Itatira**
Client:	**Empresas Nucleares Brasileiras S. A.-NUCLEBRÁS**
Contractor :	**LASA**
Survey Completion Year:	**1977**

Number of Sub-Areas:	3
Total Area (km²):	38 000
Line km:	80 000
Flight Direction:	N-S
Line Spacing (km):	0.5
Tie Line Spacing (km):	20
Flight Altitude (mtc) (m):	150
Gamma-Spectrometer:	Exploranium DIGRS-3001
Crystal Volume (in³):	1017.87
Type of Aircraft:	Islander DC-3

Back-Calibrated Sensitivities

Thorium(Th) (cps/ppm):	1.78
Potassium(K) (cps/%):	25.88
Uranium(U) (cps/ppm):	9.37
Total Count(Tc) (cps/dose rate):	51.79

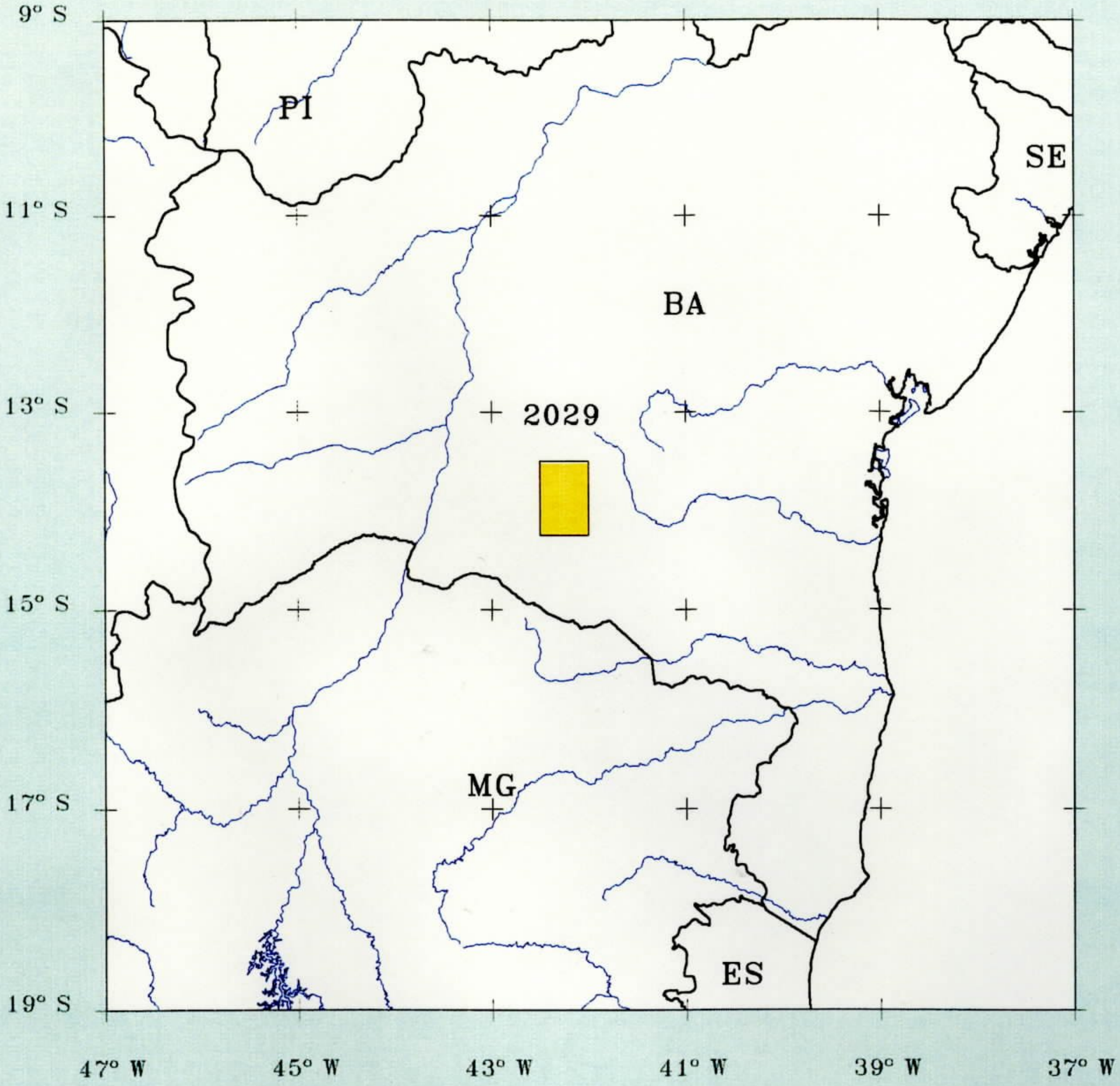
Window Sizes

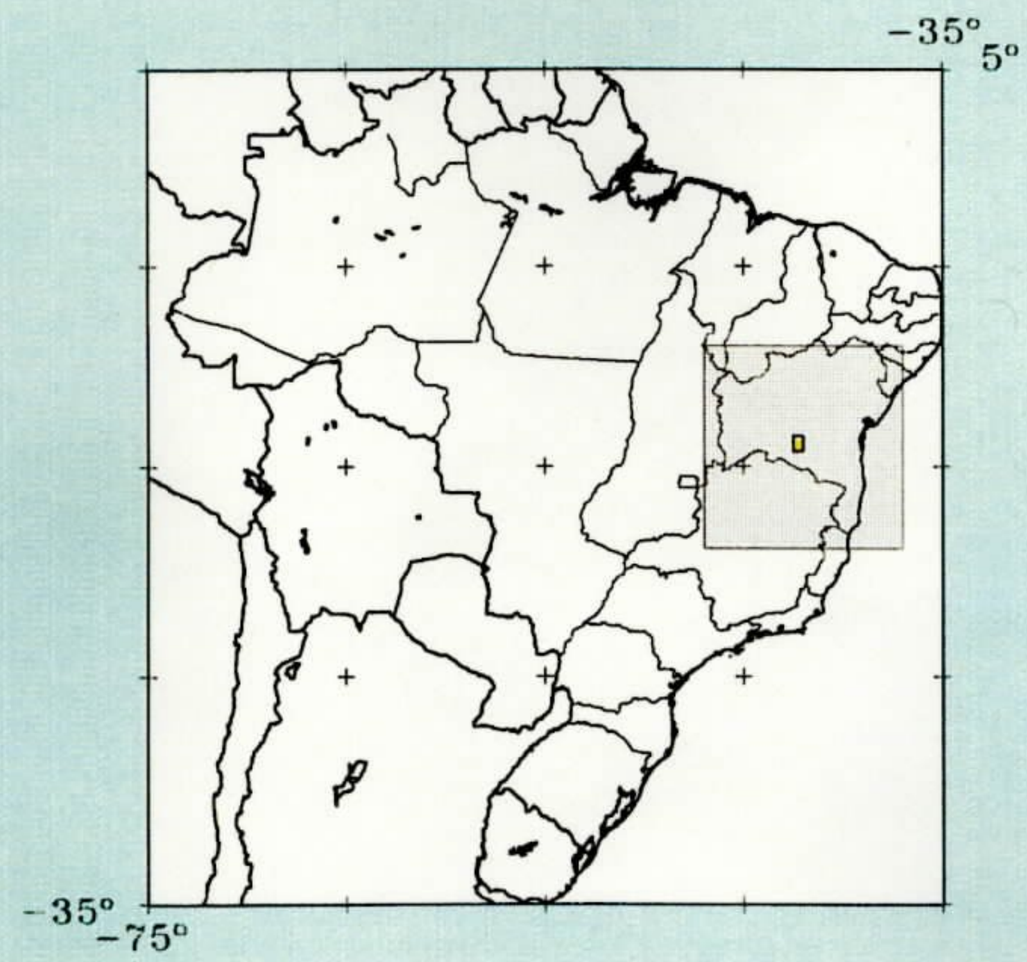
Thorium(Th) (MeV):	2.42 - 2.82	***Uranium(U) (MeV):***	1.68 - 1.88
Potassium(K) (MeV):	1.36 - 1.56	***Total Count(Tc) (MeV):***	0.90 - 2.82

Stripping Ratios

Alpha:	0.365	***Beta:***	0.5
Gamma:	0.77		

Comments: Two types of aircraft used: Islander (west of 39° 15' W) and DC-3 (east of 39° 15' W).





Sao Timoteo

#2029

SAMMP #	**4120**	***CPRM #***	**2029**

Project	**São Timóteo**
Client:	**Empresas Nucleares Brasileiras S. A.-NUCLEBRÁS**
Contractor:	**GEOFOTO**
Survey Completion Year:	**1979**

Number of Sub-Areas:	1
Total Area (km²):	4 600
Line km:	9 560
Flight Direction:	E-W
Line Spacing (km):	0.5
Tie Line Spacing (km):	10
Flight Altitude (mtc) (m):	150
Gamma-Spectrometer:	Exploranium DIGRS-3001
Crystal Volume (in³):	1017.87
Type of Aircraft:	Islander

Back-Calibrated Sensitivities

Thorium(Th) (cps/ppm):	1.70
Potassium(K) (cps/%):	23.0
Uranium(U) (cps/ppm):	6.6
Total Count(Tc) (cps/dose rate):	55.0

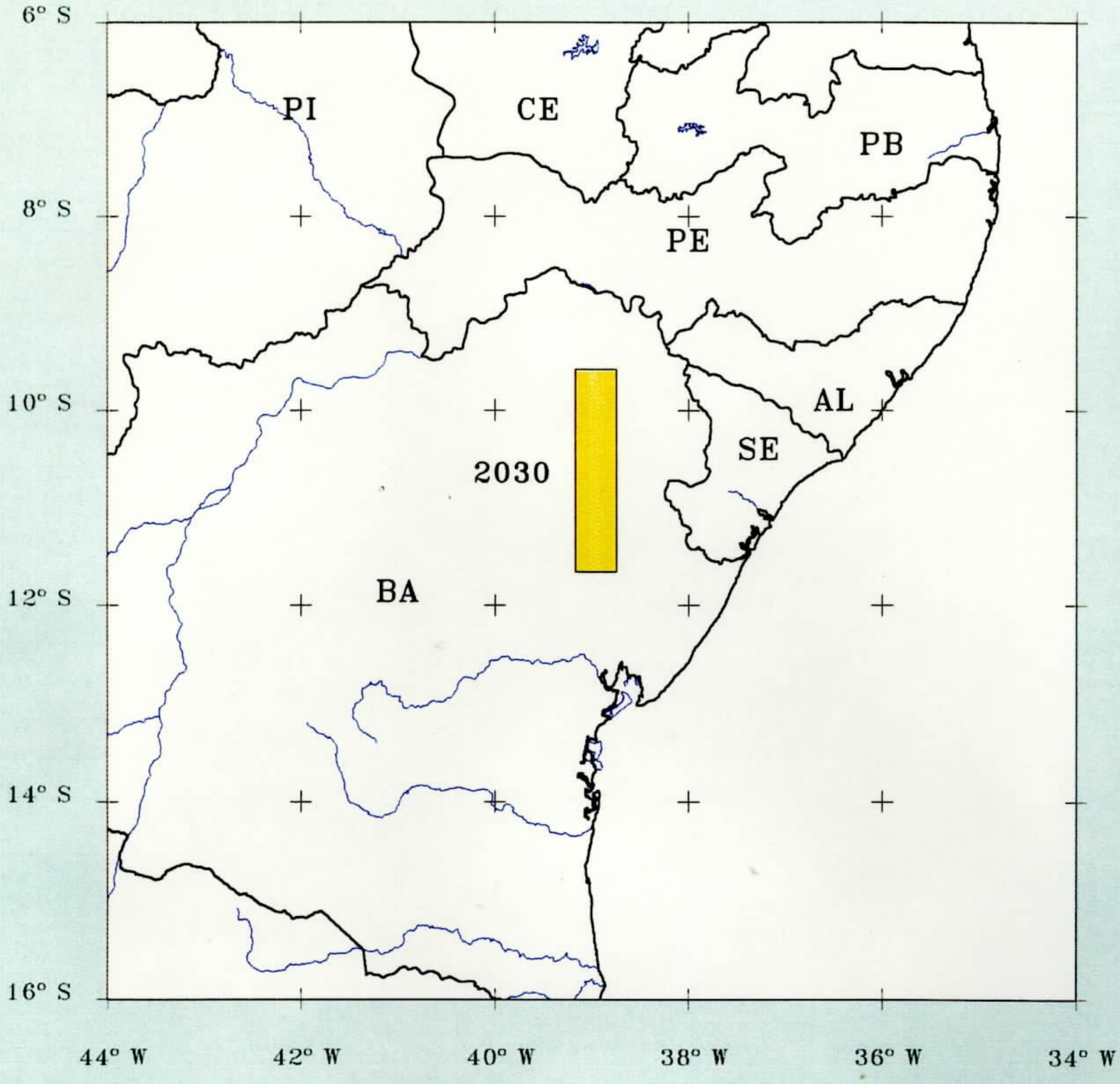
Window Sizes

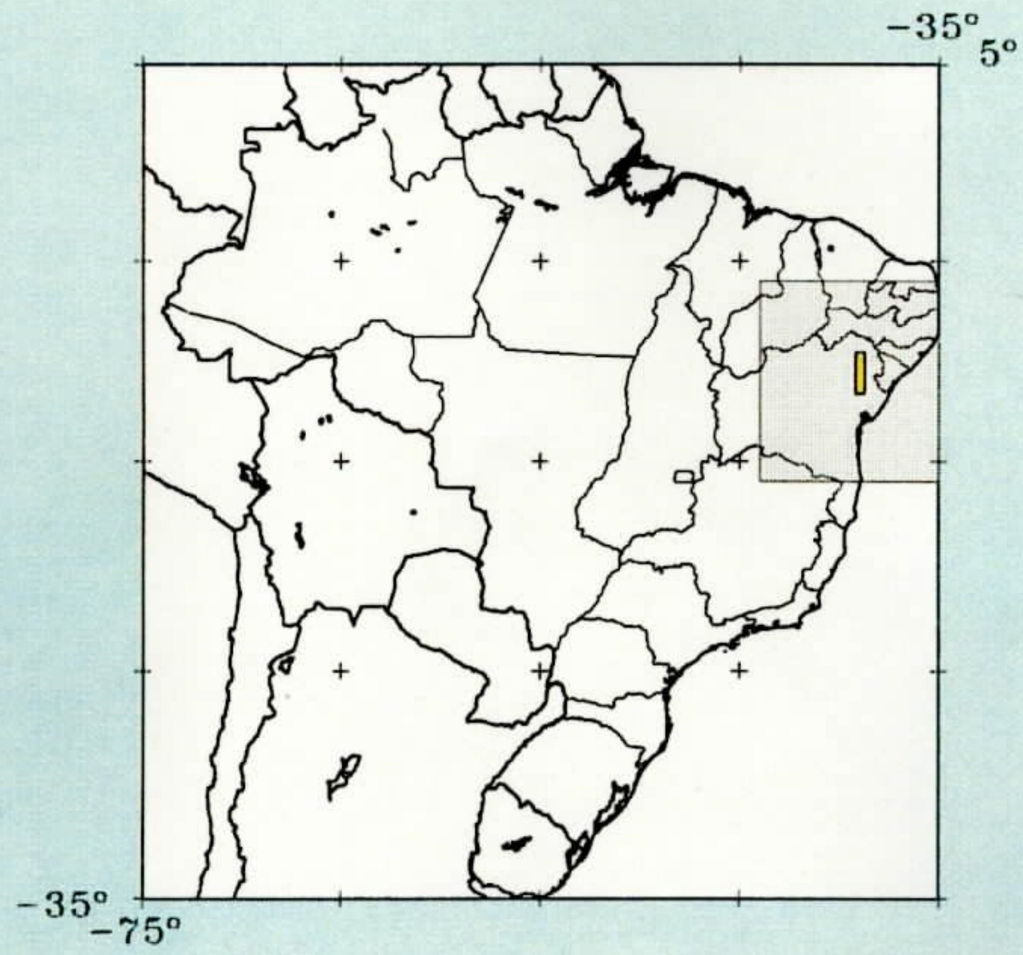
Thorium(Th) (MeV):	***Uranium(U) (MeV):***
Potassium(K) (MeV):	***Total Count(Tc) (MeV):***

Stripping Ratios

Alpha:	***Beta:***
Gamma:	

Comments: -





Borda Oeste Da Bacia De Tucano

#2030

121

SAMMP # **4135** *CPRM #* **2030**

Project	**Borda Oeste da Bacia de Tucano**
Client :	**Empresas Nucleares Brasileiras S. A.-NUCLEBRÁS**
Contractor:	**LASA**
Survey Completion Year:	**1980**

Number of Sub-Areas:	1
Total Area (km²):	11 500
Line km:	22 591
Flight Direction:	E-W
Line Spacing (km):	0.5
Tie Line Spacing (km):	15
Flight Altitude (mtc) (m):	150
Gamma-Spectrometer:	Exploranium DIGRS-3001
Crystal Volume (in³):	1017.87
Type of Aircraft:	Islander

Back-Calibrated Sensitivities

Thorium(Th) (cps/ppm):	1.50
Potassium(K) (cps/%):	17.0
Uranium(U) (cps/ppm):	11.0
Total Count(Tc) (cps/dose rate):	48.0

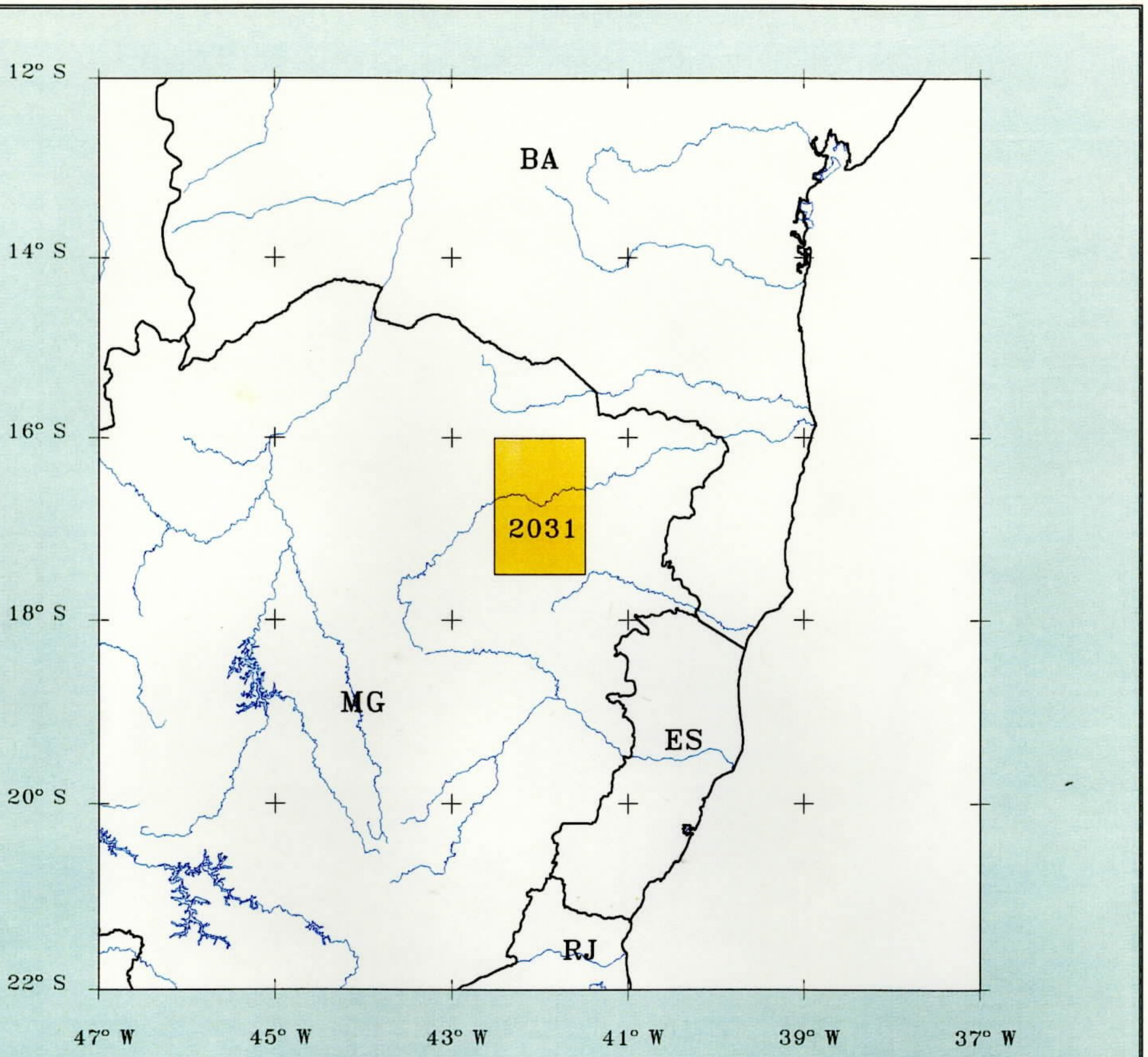
Window Sizes

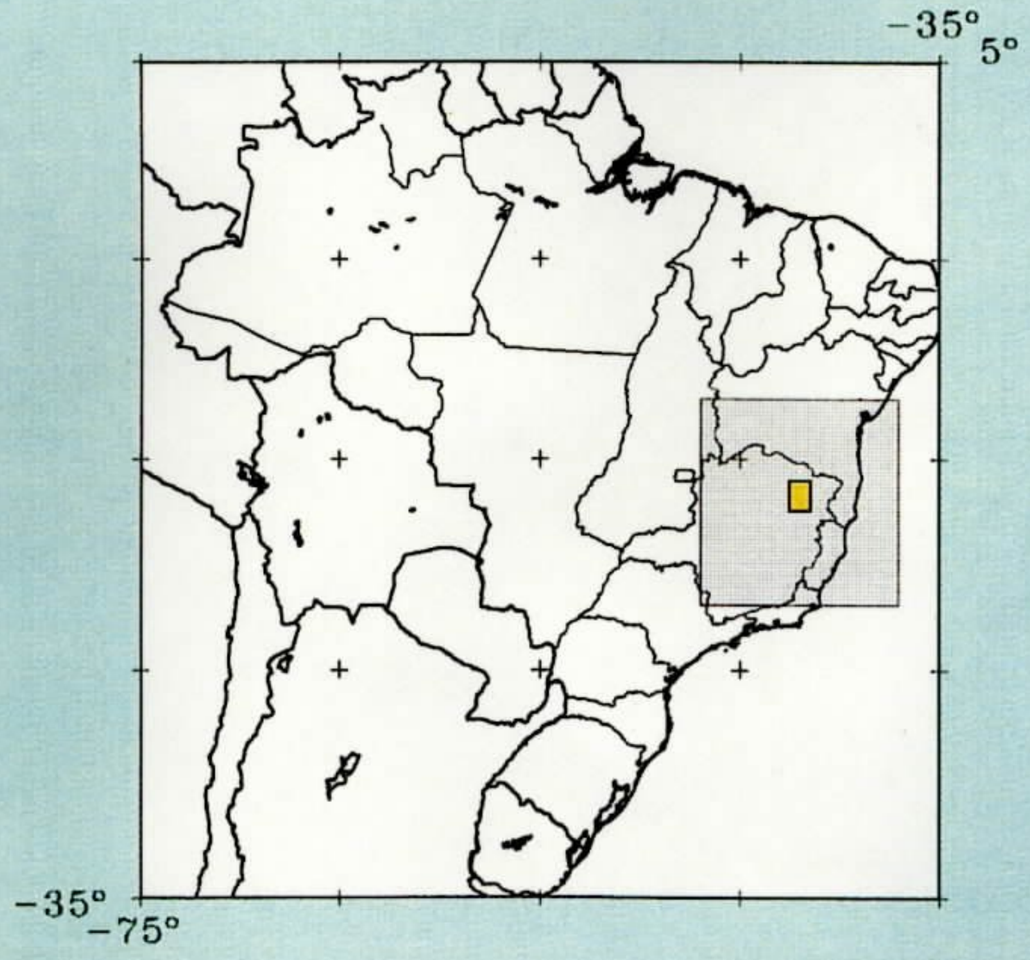
Thorium(Th) (MeV):	2.42 - 2.82	*Uranium(U) (MeV):*	1.68 - 1.88
Potassium(K) (MeV):	1.36 - 1.56	*Total Count(Tc) (MeV):*	0.90 - 2.82

Stripping Ratios

Alpha:	0.365	*Beta:*	0.5
Gamma:	0.77		

Comments: -





Aracuai

#2031

SAMMP #	**4105**
CPRM #	**2031**

Project	**Araçuaí**
Client:	**Empresas Nucleares Brasileiras S. A.-NUCLEBRÁS**
Contractor:	**PROSPEC**
Survey Completion Year:	**1982**

Number of Sub-Areas:	1
Total Area (km²):	18 000
Line km:	17 872
Flight Direction:	E-W
Line Spacing (km):	1
Tie Line Spacing (km):	20
Flight Altitude (mtc) (m):	150
Gamma-Spectrometer:	Exploranium DIGRS-3001
Crystal Volume (in³):	1024
Type of Aircraft:	Islander

Back-Calibrated Sensitivities

Thorium(Th) (cps/ppm):	1.33
Potassium(K) (cps/%):	21.92
Uranium(U) (cps/ppm):	2.78
Total Count(Tc) (cps/dose rate):	41.55

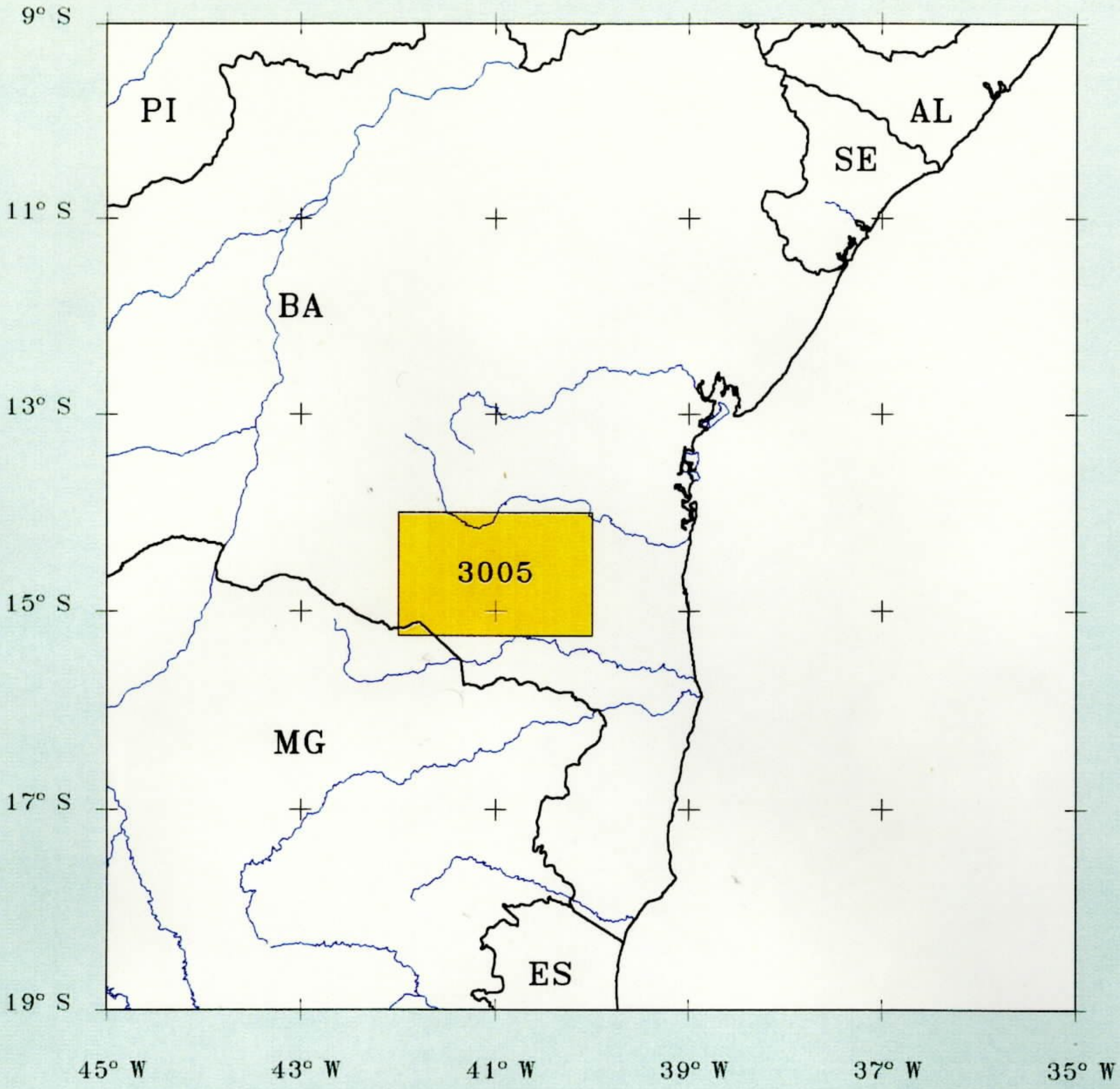
Window Sizes

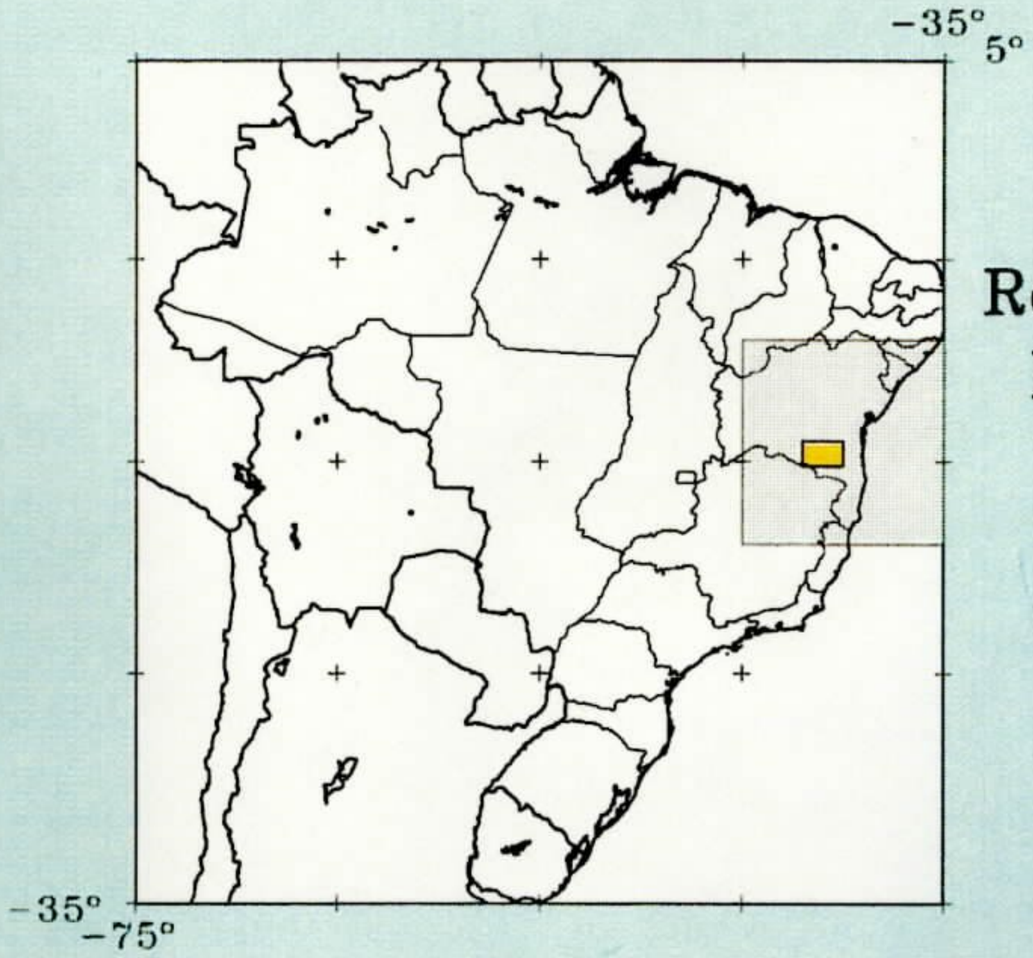
Thorium(Th) (MeV):	2.41 - 2.82	***Uranium(U) (MeV):***	1.66 - 1.86
Potassium(K) (MeV):	1.36 - 1.56	***Total Count(Tc) (MeV):***	0.78 - 2.82

Stripping Ratios

Alpha:	0.318	***Beta:***	0.22
Gamma:	0.902		

Comments: -





Rochas Basicas E Ultrabasicas De Vitoria Da Conquista-BA

#3005

SAMMP #	**4203**	***CPRM #***	**3005**

Project	**Rochas Básicas e Ultrabásicas de Vitória da Conquista-BA**
Client:	**Companhia Baiana de Pesquisa Mineral-CBPM**
Contractor:	**LASA**
Survey Completion Year:	**1975**

Number of Sub-Areas:	1
Total Area (km²):	30 250
Line km:	31 987
Flight Direction:	N-S
Line Spacing (km):	1
Tie Line Spacing (km):	22
Flight Altitude (mtc) (m):	150
Gamma-Spectrometer:	Exploranium DIGRS-3001
Crystal Volume (in³):	1017.87
Type of Aircraft:	Islander

Back-Calibrated Sensitivities

Thorium(Th) (cps/ppm):
Potassium(K) (cps/%):
Uranium(U) (cps/ppm):
Total Count(Tc) (cps/dose rate):

Window Sizes

Thorium(Th) (MeV):	2.42 - 2.82	***Uranium(U) (MeV):***	1.68 - 1.88
Potassium(K) (MeV):	1.36 - 1.56	***Total Count(Tc) (MeV):***	0.90 - 2.82

Stripping Ratios

Alpha:	0.365	***Beta:***	0.50
Gamma:	0.77		

Comments: Survey not included in BARMP. Data only available for U, K, Th, and Tc as stacked profiles maps.

ANNEX A

AIRBORNE RADIOMETRIC SURVEY GROUPS

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AIRBORNE RADIOMETRIC SURVEY GROUPS

CRYSTAL VOLUME IN CUBIC INCHES

Group 1 1024	Group 2 1017.87	Group 3 830.94	Group 4 2491.59	Group 5 1077	Group 6 3072
Survey # 1038 Part 1	Survey # 1019	Survey # 1022	Survey # 1010	Survey # 1020	Survey # 1038 Part II
1039 Part III	1021	1023			1039 Part IV
1044	1025	1027			1039 Part V1
1047	1029	1028			2024 Subarea II
1048	1031	1030			2024 Subarea III
1049	1034	1032			2026
1050	1035	1036			
1051	1037	1041			
1052	1043	1042			
1053	2014	2015			
2024 subarea I	2016				
2031	2017				
	2020				
	2021				
	2022				
	2023				
	2025				
	2027				
	2029				
	2030				
	3005				

ANNEX B

GROUND SPECTROMETER OPERATION

AND

CALCULATIONS FOR USE IN

BACK-CALIBRATION

COLLECTING THE DATA

The portable gamma-ray spectrometer was used to measure the gamma-ray spectrum at each of these sites. The spectrometer used for BARMP was the Exploranium GR-320 256 channel gamma-ray spectrometer with a 21 cubic inch detector (0.35 litres). At each site four readings were collected which were approximately 50 m apart. This was done to account for and measure the local variation of the ground radioactivity. The spectrum for each reading was stored in the internal memory of the spectrometer as a 256 channel spectrum which also calculates the ground concentration and counts per minute for each of the spectrum window (potassium, uranium, thorium and total count) for the field display. These should be monitored in the field for any irregularities. At each site it is important to take reading at locations that will be representative of the area. One important point is to avoid taking reading at a location that has been disturbed from its natural state. For example reading should be taken away from road since foreign material may have been used in the construction. Also ditches and areas that appear to be recently flooded. Also avoid if possible taking reading on outcrop or near boulders. Soil has less local variation than outcrop. This will unnecessarily increase the error in the back calibration calculation. It is also important during the reading to try and shelter the spectrometer from the sun since it can over heat. At each site a hand held GPS was used to verify the location of the site. Each reading was 100 seconds, which is the time required to get a statistically accurate reading at each reading location.

USING THE PORTABLE SPECTROMETER

Testing the spectrometer

At the beginning of each day a system test should be taken to make sure that the spectrometer is functioning properly. This is done by turning the spectrometer on, the Top Menu will then appear. Select "1 System test" in the Top menu by pressing the "1" button. Check the display to make sure the spectrometer has the correct setting, the gain stabilizer is on and stabilizing on

cesium which is channel 55. Then press "enter" to start the test. The test takes several seconds and then displays the peak, FWHM (Full Width Half Maximum) and gain for D1 and D2 which represent detector one and two. Since only detector one is being used D2 will display "not selected". The peak indicates what channel the spectrometer is stabilizing on i.e. where the cesium peak is located. The FWHM is the full width half maximum, which is a measure of the resolution of the instrument. This should be within +/- 0.5 % of the resolution given in the system calibration sheet (included in the appendix). The gain shown should be between 100 and 400 when the instrument is functioning properly. The gain will usually be near 180. Press "stop" twice to return to the top menu.

Taking a reading

At each site a 100 second measurement (reading) of the spectrum will be recorded. Each of the spectrum measured will be recorded as a 256 channel spectrum reading. This spectrum reading will be stored in the internal memory of the portable gamma spectrometer and later dumped to the computer for further processing.

Set up the detector. The spectrometer should then be turned on by pressing the "on/off" button. The top menu will then appear. A reading is taken by pressing the "start/stop" button. The main measurement display will then appear showing the spectrum in real time. The vertical scale of the spectrum can be changed by pressing the up and down arrow keys. The part of the spectrum displayed can be changed from channels 0-256, to 0-128, to 128-256 and back to 0-256 by pressing the "." key. The location of the cursor can be moved using the left and right arrow. The channel location of the cursor and the ROI# of the cursor is in along with the number of counts. This ROI# is indicated in the upper left corner of the display. ROI# 2, 3, 4 are the channel window for K, U, Th respectively. More information on the use of the spectrometer can be found in the user manual.

At the completion of the reading, the assay evaluations will be displayed. Note these values in a

field book then press enter to store the 256 channel spectrum in the internal data memory. The spectrum's record number will be displayed. Make note of its number since it will be required later when processing the data. Turn the spectrometer off by pressing the "on/off" button.

Background measurement

The background measurement was used to adjust background values in the calibration file which is used in the processing of the data. The background measurement was taken over water (large lake or ocean). The readings were taken using a boat constructed of fibreglass or aluminum, not wood as this would distort the background reading. The spectrums from these readings were then averaged and the concentrations calculated using the EXPLORE/EXPLORANIUM program. The concentrations were then used to replace the background reading in the calibration file. The format of the calibration file is shown in the Annex C.

DUMPING THE DATA FROM THE PORTABLE SPECTROMETER AND PROCESSING FIELD DATA

At the end of the field day all the data was retrieved from the spectrometer. The data consisted of a 256 channel spectrum reading for each measurement taken. The data was dumped to the field computer using the EXPLORE program following the steps below.

1) first connect the output cable from the spectrometer to the serial port on the computer.

<u>On the Spectrometer</u>

2) turn the spectrometer on
3) select from the top menu "6 Data output"
4) use the shift key to select SW HSH, then press 'enter' to return to the top menu. This puts the PC in communication with the spectrometer.
5) then put the spectrometer in remote mode by pressing "." then "CLEAR" button.

<u>On the PC</u>

6) now on the computer run program called EXPLORE in windows
7) select the appropriate communication port (should be com1) then select "O.K."
8) under the "file" menu select, "retrieve data from GR320"
9) select the working directory for this survey
10) enter a file name. This name will be used as the prefix to the reading storage number for each of the spectrum dumped. The suffix will be .asp. (For example, if the file name chosen is spec and there are 5 readings on the spectrometer then the file dumped to the PC will be spec1.asp, spec2.asp, spec3.asp, spec4.asp and spec5.asp)
11) when the data has been dumped successfully select "O.K.".

On the spectrometer

12) press "stop/start", this takes the spectrometer out of remote mode
13) select from the top menu "6 Data output"
14) press the "shift" button three times to select data memory. This puts it back into the normal operating mode
15) then press "enter" to return to the top menu
16) turn the spectrometer off and disconnect the cable.

The EXPLORE program has retrieved all the spectra that were stored in the internal data memory of the portable spectrometer. For each of the 256 channel spectra stored on the spectrometer (i.e. each reading) a spectrum files (*.asp files) has been created on the PC.

To convert each of the 256 channel spectra (*.asp) to ground concentrations the explore program was used once again.

On the PC

17) In the EXPLORE program under the "Analyse Spectrum Data" menu select calculate counts/concentration
18) select the directory which contains the spectra files that were dumped.
19) in the box located under the title "file for processing" enter the prefix used for the spectra files. This will be the same as the file name entered at step 10.
20) under process spectrum from: enter reading numbers that were used. For example 1 to 80. Then select "O.K."
21) the next window select the calibration file to be used to calculate the concentrations. Then select "O.K."
22) after the calibration parameters are shown select "O.K."

The EXPLORE program has now created two new files: a counts file (*.cts) and a concentration file (*. con).

The counts file *.cts is created from the asp files by windowing each of the spectra individually and calculating the counts in each of the windows i.e. one for each of uranium, potassium, and thorium. The calibration file was then used to convert the counts in the counts file (*.cts) into ground concentrations of the concentration file (*.con). The calibration file contains all the values required to process these spectra into concentration (i.e. the stripping ratios, background, sensitivities). The calibration file was created when the spectrometer was calibrated and updated for the background at each of the survey areas.

CALCULATING THE SENSITIVITIES

The sensitivities for each of the back-calibrated survey areas were calculated using a program called "sense.bas".

Before calculating the back-calibrated sensitivities a folder was created for each of the surveys that were back-calibrated. The folders contained copies of the sense.bas program as well as the ground concentration (*.con), back-calibration site location (*.loc) and the airborne data (*.xyz) files pertaining to the survey.

The *.con file was the file created by the EXPLORE program. It contained the ground concentration for potassium (in %), uranium (in ppm) and thorium (in ppm) for each of the ground readings (four readings at each site for approximately 80 readings). It is an ASCII file with the format:

reading #, potassium, uranium, thorium. An example of the concentration file is included in Annex C.

The *.xyz file was the airborne radiometric data in xyz ASCII format (the line header used was line #, -9999, -9999, -9999, -9999, -9999 and the data was in the format x, y, k, u, th, total). The xyz file was exported from an oasis database file by extracting only the lines that crossed the back-calibration sites (these are the same as the line # listed in the site location file). Exporting only the lines necessary made the exporting from oasis faster and greatly improved the speed at which the sense program ran since the sense program searches the entire xyz file looking for data for each site. An example of the airborne xyz data file is included in the Annex C.

The *.loc file was the site location file. It contained the location of all the sites where the ground reading were taken. The file was an ASCII file that was created manually using a text editor. The file was in the format (site #, x, y, line #). The site # was the number designated for the back-calibration site with the x, y being the coordinates of the point. The line # corresponded to flight line number which passes above this particular site. An example of the location file is included in the Annex C.

The output of the sense.bas program was a file *.sen file. The *.sen file was an ASCII file which contained the calculated sensitivities for each site and average of all the sites. At the bottom of the file the "final" weighted average sensitivities for each of potassium, uranium, thorium and total count are given along with their calculated error. The *.sen file also contains, for each of the back-calibration sites: the calculated sensitivities and their respective errors, the averaged ground concentration and their respective errors, and the average airborne data and their respective errors. An example of the airborne xyz data file is included in the Annex C.

RUNNING THE SENSE.BAS PROGRAM

The sense.bas program was run out of a DOS window.

Open a DOS window then change to the directory that contains the working directory to the directory that contains the *.loc, *.con, *.xyz and sense program. The sense.bas program can

then be run using the command:

qbasic/run sense.bas

The program will then request for the names of the three files mentioned above, airborne xyz file (*.xyz), site location file (*.loc) and the ground concentration file (*.con). The program will also request for the name of the output file (*.sen) which will contain the back-calibrated sensitivities. It will then request for the number of sites used in the back-calibration (20 for most of the projects back-calibrated for BARMP). Once you have entered this information it will automatically calculate the sensitivities which are listed in the *.sen file.

The sense program calculates the sensitivities given in the *.sen file by using the formulas as explained in sensitivities calculations.

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ANNEX C

SAMPLE CALCULATIONS OF SENSITIVITY COEFFICIENTS

CALIBRATION FILE

The calibration file contains the stripping ratios, sensitivities and backgrounds necessary to convert the field data from counts to ground concentrations.

Sample file:

```
.487     .622     1.104     .037
3.443    .298     .142
.815     .304     .112
```

File format:

.487 = ALPHA stripping coefficient
.622 = BETA stripping coefficient
1.104 = GAMMA stripping coefficient
.037 = A stripping coefficient

3.433 = K sensitivities in cts/sec/%
.298 = U sensitivities in cts/sec/ppm
.142 = Th sensitivities in cts/sec/ppm

.815 = K background in cts/sec
.304 = U background in cts/sec
.112 = Th background in cts/sec

AIRBORNE RADIOMETRIC DATA (*.XYZ)

The airborne radiometric data file(*.xyz) contain the airborne data in the format:
X Y K U Th Total Count

Sample:

24 -9999 -9999 -9999 -9999 -9999
374294.0000 6625938.0000 521.0000 170.0000 126.0000 5253.0000
374414.0000 6625821.0000 507.0000 139.0000 129.0000 4909.0000
374535.0000 6625704.0000 458.0000 95.0000 124.0000 4609.0000
374574.0000 6625900.0000 690.0000 253.0000 143.0000 6541.0000
374698.0000 6625784.0000 538.0000 143.0000 127.0000 5176.0000
374821.0000 6625669.0000 575.0000 144.0000 117.0000 4952.0000
374945.0000 6625554.0000 695.0000 113.0000 111.0000 5559.0000
375068.0000 6625439.0000 777.0000 171.0000 153.0000 5985.0000
375192.0000 6625323.0000 705.0000 112.0000 124.0000 5379.0000
375315.0000 6625208.0000 710.0000 158.0000 125.0000 5407.0000
375433.0000 6625111.0000 500.0000 166.0000 234.0000 5822.0000
375551.0000 6625013.0000 583.0000 213.0000 365.0000 7959.0000
375668.0000 6624916.0000 666.0000 238.0000 389.0000 9107.0000
375786.0000 6624818.0000 735.0000 283.0000 464.0000 10151.0000
25 -9999 -9999 -9999 -9999 -9999
379945.0000 6619348.0000 671.0000 156.0000 416.0000 8460.0000
379844.0000 6619455.0000 802.0000 118.0000 490.0000 9100.0000
379743.0000 6619562.0000 734.0000 116.0000 422.0000 8369.0000
379642.0000 6619669.0000 650.0000 212.0000 408.0000 8704.0000
26 -9999 -9999 -9999 -9999 -9999
371623.0000 6625966.0000 522.0000 115.0000 131.0000 4928.0000
371764.0000 6625816.0000 402.0000 126.0000 141.0000 4502.0000
371905.0000 6625665.0000 454.0000 107.0000 129.0000 4557.0000
372045.0000 6625515.0000 622.0000 154.0000 125.0000 5175.0000
372186.0000 6625365.0000 555.0000 156.0000 96.0000 4654.0000
372327.0000 6625214.0000 442.0000 135.0000 91.0000 4032.0000
372468.0000 6625064.0000 547.0000 126.0000 94.0000 4539.0000
372608.0000 6624913.0000 754.0000 184.0000 116.0000 5374.0000
372749.0000 6624763.0000 963.0000 179.0000 103.0000 5946.0000
372876.0000 6624646.0000 859.0000 222.0000 99.0000 6077.0000
27 -9999 -9999 -9999 -9999 -9999
371034.0000 6625058.0000 597.0000 163.0000 119.0000 5427.0000
370943.0000 6625149.0000 664.0000 129.0000 106.0000 5561.0000
370852.0000 6625240.0000 673.0000 105.0000 110.0000 5307.0000
370760.0000 6625330.0000 626.0000 112.0000 89.0000 4760.0000
370669.0000 6625421.0000 566.0000 126.0000 102.0000 4880.0000
370577.0000 6625511.0000 622.0000 135.0000 96.0000 5049.0000
370486.0000 6625602.0000 611.0000 97.0000 111.0000 4976.0000
370373.0000 6625718.0000 575.0000 92.0000 124.0000 4835.0000
370259.0000 6625833.0000 605.0000 107.0000 107.0000 4805.0000

SITE LOCATION FILE(*.LOC)

The site location file contains all the coordinates of the back-calibration sites. The format is:
SITE #, X, Y, LINE #

Sample:
1,362913,6606390,46
2,363295,6604650,47
3,363769,6600047,50
4,365792,6598097,50
5,363815,6602801,48
6,369811,6618080,33
7,371490,6617749,32
8,373572,6617128,31
9,374049,6618077,30
10,375068,6618451,29
11,375640,6619397,28
12,376195,6620281,27
13,376928,6620852,26
14,377869,6621486,25
15,378457,6622427,24
16,358114,6630187,32
17,358637,6631073,31
18,358993,6633436,29
19,359470,6634395,28
20,359852,6635401,27

GROUND CONCENTRATION FILE(*.CON)

The ground concentration file contains all the ground concentration readings from the back-calibration. The format is:

reading #	k (%)	u(ppm)	th(ppm)
Sample:			
1	1.58	3.47	15.76
2	.89	3.73	15.66
3	.78	4.9	14.14
4	1.85	3.68	18.12
5	2.13	3.57	14.47
6	1.89	3.3	13.69
7	1.96	3.67	15.03
8	2.22	3.51	19.13
9	.89	2.71	17.09
10	1.66	2.68	12.65
11	1.26	2.44	16.17
12	.74	2.34	14.53
13	4.63	2.3	10.2
14	4.4	1.98	11.86
15	4.11	.86	14.82
16	4.35	1.12	15.16
17	2.6	2.54	27.02
18	1.55	2.13	23.75
19	2.09	2.87	22.2
20	3.21	2.85	26.6
21	1.04	5.05	10.54
22	.87	3.72	7.85
23	1.42	4.69	13.58
24	1.13	4.84	10.85
25	3.84	4.64	14.1
26	3.64	4.32	12.98
27	4.25	4.79	14.1
28	3.13	4.46	13.4
29	2.93	5.29	33.87
30	3.09	5.72	62.29
31	4.13	7.88	52.64
32	3.63	5.49	59.86
33	2.78	4.06	32.09
34	3.33	5.56	53.62
35	2.85	6.86	30.79
36	1.94	3.91	31.36
37	3.29	5.18	40.45
38	3.03	4.11	32.56
39	3	3.75	27.51
40	3.97	4.56	29.45
41	3.14	3.96	23.72
42	3.89	5.02	25.37
43	2.77	3.7	23.96
44	1.66	4.13	23.53
45	3.04	2.77	22.94
46	1.6	2.46	15.54
47	2.78	2.2	17.87
48	2.88	3	16.02

49	.57	1.59	18.12
50	.43	1.96	19.58
51	.7	2.84	26.68
52	.75	2.69	15.74
53	.41	3.55	19.84
54	.35	4.3	28.68
55	.19	2.31	17.19
56	.29	1.92	12.99
57	1.61	5.13	24.54
58	2.61	4.82	26.25
59	3.29	4.74	26.62
60	1.91	4.17	20.75
61	1.74	5.79	35.67
62	2.22	4.66	35.85
63	3.49	4.88	29.87
64	3.39	5.68	31.04
65	3.65	6.34	14.92
66	2.66	7.85	15.96
67	3.67	6.2	11.7
68	3.88	10.14	8.75
69	1.49	3.7	23.65
70	1.7	5.41	21.15
71	1.2	5.91	21.89
72	1.24	5.24	20.07
73	1.49	4.69	28.25
74	1.59	5.15	34.12
75	.88	4.47	26.82
76	1.13	4.16	21.97
77	2.52	1.99	10.34
78	2.97	1.7	14.1
79	2.2	1.61	11.24
80	2.49	1.75	10.94

SENSITIVITY FILE (*.SEN)

The sensitivity file(*.sen) is the output from the sense.bas program and contains all the sensitivities calculated for the back-calibration.
Sample:

TOTAL COUNT

SITE	AIRBORNE COUNTS - TOTAL		
1	6196.167	+/-	303.3862
2	6225	+/-	612.7385
3	5047.167	+/-	544.5078
4	5852.25	+/-	334.9626
5	5541.333	+/-	785.0591
6	5858.75	+/-	658.1259
7	5308.667	+/-	221.0363
8	7858.333	+/-	899.2939
9	7430.25	+/-	340.4886
10	7042.75	+/-	692.4841
11	7103.286	+/-	722.8569
12	7861.833	+/-	976.2217
13	7312.333	+/-	494.5008
14	5816.167	+/-	1185.132
15	5115.667	+/-	1217.57
16	6369.429	+/-	1808.625
17	7552.625	+/-	729.4551
18	6498.125	+/-	940.0787
19	6360.625	+/-	543.4131
20	4789.125	+/-	440.4773

SITE	GROUND CONCENTRATIONS - TOTAL (uR/Hr)		
1	9.064	+/-	.9650038
2	9.850372	+/-	.9188493
3	7.70876	+/-	.6067225
4	11.33643	+/-	.2598033
5	12.39588	+/-	1.736551
6	7.737885	+/-	1.287933
7	12.47997	+/-	.9239777
8	24.13612	+/-	4.368889
9	18.03875	+/-	4.194685
10	17.19891	+/-	2.115036
11	13.98567	+/-	1.856412
12	10.77062	+/-	1.836243
13	8.152733	+/-	1.619204
14	8.085335	+/-	2.668649
15	13.66615	+/-	1.840364
16	17.01028	+/-	.502052
17	13.88177	+/-	.8417462
18	11.65076	+/-	.5013163
19	12.90607	+/-	2.076719
20	8.326122	+/-	.8934231

SITE AIRBORNE SENSITIVITIES - TOTAL (CPS/uR/hr)

1	683.6017	+/-	80.10793
2	631.9558	+/-	85.69964
3	654.7313	+/-	87.4342
4	516.2341	+/-	31.82798
5	447.0303	+/-	89.0666
6	757.1514	+/-	152.0394
7	425.3749	+/-	36.13205
8	325.584	+/-	69.72433
9	411.905	+/-	97.62544
10	409.4882	+/-	64.47433
11	507.8973	+/-	84.94935
12	729.9332	+/-	153.9524
13	896.9181	+/-	188.179
14	719.3477	+/-	279.0291
15	374.3312	+/-	102.3662
16	374.4457	+/-	106.8982
17	544.0677	+/-	62.04541
18	557.7425	+/-	84.18153
19	492.8398	+/-	89.78761
20	575.1927	+/-	81.29037

POTASSIUM

SITE AIRBORNE COUNTS - POTASSIUM

1	517.8333	+/-	73.3578
2	642	+/-	109.466
3	499.6667	+/-	65.823
4	834.75	+/-	59.23611
5	582	+/-	97.23579
6	625.75	+/-	112.9738
7	634.8333	+/-	52.05542
8	747.6667	+/-	176.0212
9	674	+/-	176.4467
10	603.375	+/-	89.70895
11	625.7143	+/-	111.7717
12	781.1667	+/-	157.2583
13	622	+/-	81.89262
14	456	+/-	207.9202
15	340	+/-	216.1749
16	573.5714	+/-	141.3658
17	742.375	+/-	52.92566
18	375.375	+/-	127.8291
19	562	+/-	136.2571
20	500.75	+/-	48.293

SITE GROUND CONCENTRATIONS - POTASSIUM (PCT)

1	1.275	+/-	.5218238

2	2.05	+/-	.1516601
3	1.1375	+/-	.4112072
4	4.3725	+/-	.2132791
5	2.3625	+/-	.7092427
6	1.115	+/-	.2301446
7	3.715	+/-	.4653692
8	3.445	+/-	.5461075
9	2.725	+/-	.57761
10	3.3225	+/-	.4508787
11	2.865	+/-	.9286729
12	2.575	+/-	.6587617
13	.6125	+/-	.1433817
14	.31	+/-	9.380832E-02
15	2.355	+/-	.7510659
16	2.71	+/-	.8663717
17	3.465	+/-	.5466558
18	1.4075	+/-	.2334342
19	1.2725	+/-	.3278588
20	2.545	+/-	.3179645

SITE AIRBORNE SENSITIVITIES - POTASSIUM (CPS/PCT)

1	406.1438	+/-	175.8997
2	313.1707	+/-	58.20766
3	439.2674	+/-	169.0104
4	190.9091	+/-	16.43919
5	246.3492	+/-	84.63742
6	561.2108	+/-	153.898
7	170.8838	+/-	25.58453
8	217.0295	+/-	61.59786
9	247.3395	+/-	83.31492
10	181.6027	+/-	36.55635
11	218.3994	+/-	80.83087
12	303.3657	+/-	98.75726
13	1015.51	+/-	272.7429
14	1470.968	+/-	804.9778
15	144.3737	+/-	102.6948
16	211.65	+/-	85.43685
17	214.2496	+/-	37.09205
18	266.6963	+/-	101.0183
19	441.6503	+/-	156.2502
20	196.7584	+/-	31.05429

URANIUM

SITE AIRBORNE COUNTS - URANIUM

1	105.5	+/-	29.4805
2	107	+/-	32.9363
3	70	+/-	21.40093
4	73	+/-	39.13226
5	76	+/-	22.70683
6	129.25	+/-	29.62021
7	89.5	+/-	16.05927
8	69.33334	+/-	21.64871
9	97.375	+/-	22.42408
10	99.375	+/-	40.32347
11	131.4286	+/-	30.20407
12	151.5	+/-	27.52998
13	113.8333	+/-	23.9868
14	123	+/-	17.22788
15	130.3333	+/-	29.13875
16	104.5714	+/-	30.18199
17	150.625	+/-	27.39102
18	141.625	+/-	48.98378
19	110.375	+/-	31.71722
20	94.75	+/-	17.11098

SITE GROUND CONCENTRATIONS - URANIUM (PPM)

1	3.945	+/-	.6465543
2	3.5125	+/-	.1562801
3	2.5425	+/-	.1811763
4	1.565	+/-	.6849576
5	2.5975	+/-	.3463508
6	4.575	+/-	.5888104
7	4.5525	+/-	.2054959
8	6.095	+/-	1.2029
9	5.0975	+/-	1.391269
10	4.4	+/-	.6166019
11	4.2025	+/-	.5729683
12	2.6075	+/-	.3503685
13	2.27	+/-	.5943625
14	3.02	+/-	1.100515
15	4.715	+/-	.4003724
16	5.2525	+/-	.5661185
17	7.6325	+/-	1.830984
18	5.065	+/-	.9533997
19	4.6175	+/-	.4162824
20	1.7625	+/-	.1623515

SITE AIRBORNE SENSITIVITIES - URANIUM (CPS/PPM)

1	26.74271	+/-	8.663363
2	30.46263	+/-	9.474331
3	27.53196	+/-	8.642897

4	46.64537	+/-	32.28034
5	29.25891	+/-	9.572873
6	28.25136	+/-	7.425488
7	19.65953	+/-	3.63748
8	11.37545	+/-	4.201912
9	19.1025	+/-	6.821577
10	22.58523	+/-	9.695567
11	31.2739	+/-	8.356796
12	58.10163	+/-	13.13095
13	50.14684	+/-	16.85406
14	40.72848	+/-	15.90038
15	27.64227	+/-	6.610751
16	19.90889	+/-	6.133792
17	19.73469	+/-	5.940691
18	27.9615	+/-	11.01049
19	23.90363	+/-	7.199028
20	53.75887	+/-	10.89836

THORIUM

SITE AIRBORNE COUNTS - THORIUM

1	300.5	+/-	34.23886
2	260.3333	+/-	34.19746
3	229.1667	+/-	24.55538
4	235.25	+/-	45.60976
5	256.1667	+/-	42.41423
6	233.625	+/-	43.8795
7	192.3333	+/-	23.91373
8	388.1667	+/-	18.32394
9	363.25	+/-	32.82747
10	364.875	+/-	44.54352
11	362.4286	+/-	34.597
12	369.3333	+/-	57.9333
13	345.1667	+/-	21.44217
14	288.8333	+/-	50.95259
15	278.6667	+/-	63.5568
16	305.1429	+/-	120.8407
17	237.625	+/-	36.21735
18	326	+/-	48.30853
19	278.125	+/-	19.80936
20	158.375	+/-	20.52829

SITE GROUND CONCENTRATIONS - THORIUM (PPM)

1	15.92	+/-	1.64333
2	15.58	+/-	2.429618
3	15.11	+/-	1.952098
4	13.01	+/-	2.388672

5	24.8925	+/-	2.309167
6	10.705	+/-	2.342712
7	13.645	+/-	.5526453
8	52.165	+/-	12.86676
9	36.965	+/-	11.11607
10	32.4925	+/-	5.698207
11	24.145	+/-	.8353909
12	18.0925	+/-	3.384202
13	20.03	+/-	4.707336
14	19.675	+/-	6.632792
15	24.54	+/-	2.684173
16	33.1075	+/-	3.100741
17	12.8325	+/-	3.270487
18	21.69	+/-	1.505277
19	27.79	+/-	5.00312
20	11.655	+/-	1.672392

SITE AIRBORNE SENSITIVITIES - THORIUM (CPS/PPM)

1	18.87563	+/-	2.902031
2	16.70946	+/-	3.40702
3	15.16656	+/-	2.545632
4	18.08224	+/-	4.828284
5	10.29092	+/-	1.953101
6	21.82391	+/-	6.293792
7	14.09552	+/-	1.843203
8	7.441132	+/-	1.868705
9	9.826863	+/-	3.08568
10	11.22951	+/-	2.399489
11	15.0105	+/-	1.5241
12	20.41362	+/-	4.983285
13	17.23248	+/-	4.188974
14	14.68022	+/-	5.585593
15	11.35561	+/-	2.872361
16	9.216729	+/-	3.750635
17	18.51744	+/-	5.498881
18	15.02997	+/-	2.459378
19	10.0081	+/-	1.937668
20	13.58859	+/-	2.62758

TOTAL COUNT SENSITIVITY =	498.7839	+/-	15.85613
POTASSIUM SENSITIVITY =	203.822	+/-	10.35096
URANIUM SENSITIVITY =	23.31454	+/-	1.636142
THORIUM SENSITIVITY =	12.98945	+/-	.5861501