

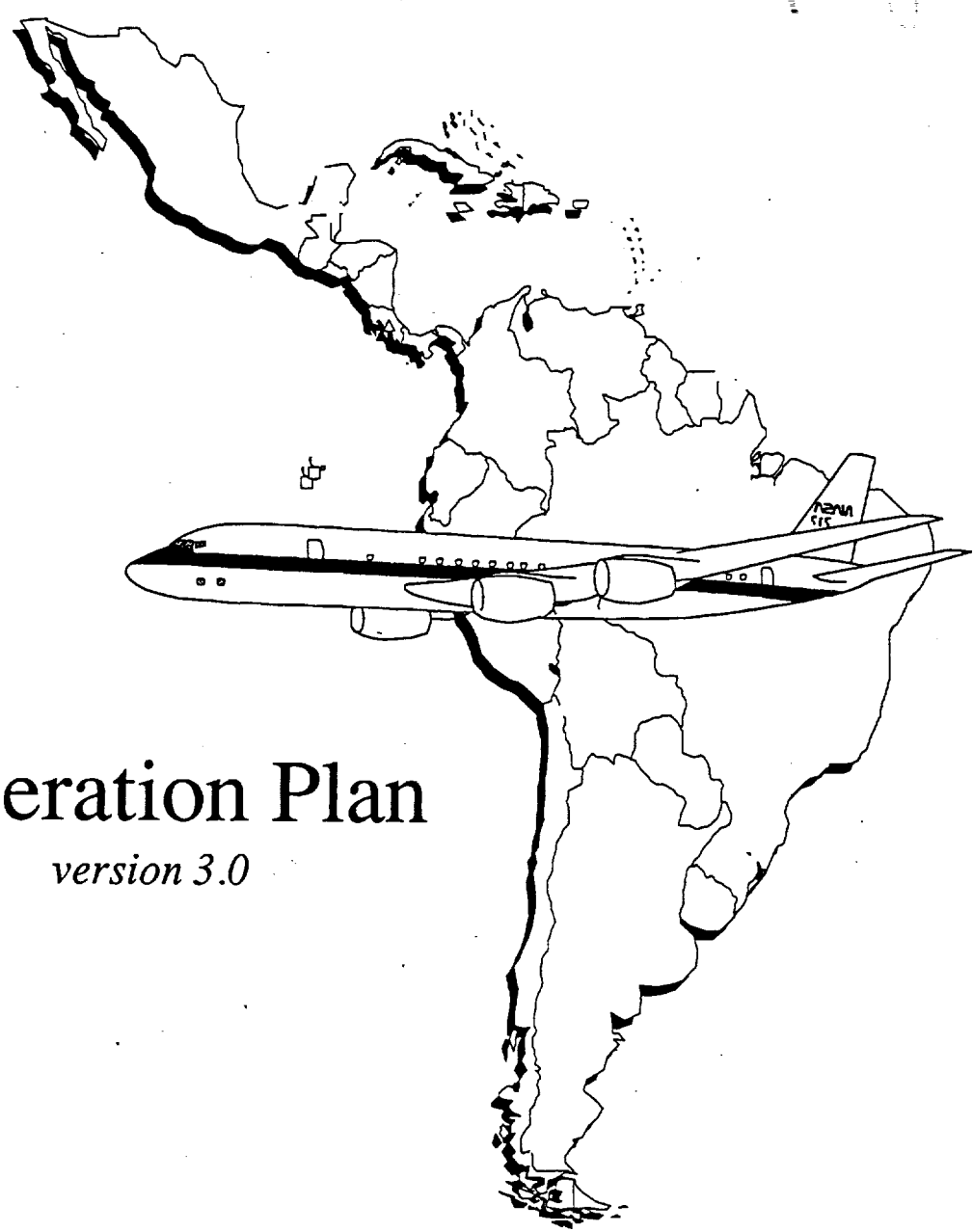
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AIRSAR South American Deployment

M. Kobrick

Jet Propulsion Laboratory
California Institute of Technology
Pasadena, California



Operation Plan version 3.0

AIRSAR South American Deployment

The United States National Aeronautics and Space Administration (NASA) and the Brazilian Commission for Space Activities (COBAE) are undertaking a joint experiment involving NASA's DC-8 research aircraft and the Airborne Synthetic Aperture Radar (AIRSAR) system during late May and June 1993. The research areas motivating these activities are: (1) fundamental research in the role of soils, vegetation, and hydrology in the global carbon cycle, and (2) in cooperation with South American scientists, airborne remote sensing research for the upcoming NASA Spaceborne Imaging Radar (SIR)-C/X-SAR flights on the Space Shuttle.

The following pages show a flight schedule and plans for the deployment that were developed at the Ames Research Center and the Jet Propulsion Laboratory (JPL) by using the flight requests received and approved by NASA Headquarters in response to a Dear Colleague letter dated May 29, 1992. The approved Principal Investigators (PIs), investigation titles, and approximate site locations are also listed.

The plan development included an attempt to accommodate all data requirements in the approved requests within the resources available, with the primary limitations being the length of the deployment (37 days) and the total number of DC-8 flight hours available within that time frame. The only major restriction imposed by those limits was the deletion of the sites south of about 24°S latitude. Most of the other approved data requests are accommodated by this plan, subject to some caveats listed below.

Included in the following pages are maps of the site locations and schematic indications of flight routes and dates, plots showing swath locations derived from the flight requests and generated by flight planning software and, most importantly, a calendar showing which sites will be imaged each day. Although the scheduling may not follow any obvious logical pattern, it is the result of incorporating a large number of disparate and sometimes conflicting requirements such as the desire to acquire multitemporal data at sites, coordination with satellite overflights, and so on. It should also be understood that the schedule is not set in concrete and will continue to evolve in response to changing PI experiment plans, changes imposed by the acquisition of international flight clearances, and any anomalies experienced during the deployment itself. Every attempt will be made to coordinate any and all such changes with the PIs involved, and the establishment and maintenance of good lines of communication both during the planning and operations phases will be of utmost importance.

The schedule has been developed based upon the following assumptions:

1. Both the DC-8 and the AIRSAR systems will function normally and any hardware problems will be minimal. A small amount of margin has been built into each day's flight plan, but since the deployment cannot be extended beyond the planned number of days, any major hardware anomalies will necessarily result in the loss of data. Although historically the reliability of both systems has been exceptionally high, and in fact the AIRSAR has not failed to acquire planned data due to hardware or system problems in its five years of operation, it must be remembered that the deployment is done on a best-effort basis and aircraft or radar problems could result in schedule changes or, in the worst case, the deletion of some sites.

2. Clearance will be obtained through the NASA International Affairs Office to overfly and acquire radar imaging data from each of the countries involved. At this writing, this has not yet been completed and historically it has been difficult to obtain flight clearance for some countries.
3. There will be no significant problems with Air Traffic Control (ATC) or with flying into military or other restricted flight zones. The DC-8 flies at the same altitudes as commercial air traffic and each day's flight plan must be cleared and approved by the proper ATC authorities. In the past, this has occasionally resulted in changes to flight plans or take-off times to minimize interference with other air traffic, particularly in foreign countries. Work so far indicates that no sites violate any military or restricted flight zones, but a final determination will have to wait for the development of more detailed flight plans by the DC-8 navigators.
4. Unless otherwise requested by the PI, all AIRSAR data will be acquired in the standard three-frequency quad-polarization mode. Where TOPSAR mode data have been requested, C-band polarimetric data will not be acquired but, instead, a CVV image will be produced along with a digital topographic map registered to the C-band image and L- and P-band polarimetric data sets. Note that although JPL has developed operational TOPSAR processor software, hardware for the systematic processing of TOPSAR data is not yet available. Thus processing of all TOPSAR mode data will be done by arrangement as special products outside the normal AIRSAR processing system.

In addition to AIRSAR, two other interesting and important experiments will also be installed on the DC-8 and will acquire data during this deployment: the lightning detection and lidar experiments, which will utilize upward-looking optical sensors and will prefer to have data acquired during dark conditions, i.e., during early evening or night and with no moon. Since AIRSAR flights generally have morning takeoffs so that during the daylight the video and film cameras may operate and the PIs collecting surface truth data at ground sites may work, some adjustments will be made.

The plan for the deployment will be to have afternoon takeoffs whenever weather forecasts indicate that a thunderstorm imaging opportunity will occur. This will allow the acquisition of: SAR data during daylight, and lightning and lidar data during the latter part of the flight in the early evening. These opportunities are most likely to occur during mid June 1993, and in the central and western portions of Brazil, Bolivia, and Peru. Unfortunately this means that exact take-off times cannot yet be determined for each flight, but every attempt will be made to coordinate take-off and overflight times with the PIs in the field during the deployment itself.

| PI Affiliation | Title | Site | approx Lon, Lat | |
|---|---|--------------------------|-----------------|--------|
| John R. Baker British National Space Centre | AIRSAR Estimation of Tropical Forest Biomass for Carbon Cycle Studies | Manaus-Reserva Du. | -59.57 | -2.57 |
| | | Sena Maduriera | -68.67 | -9.25 |
| | | Rio Tapajos | -55.00 | -3.50 |
| Paolo Canuti Univ. of Florence | Contribution of SAR for Estimating Soil Erosion | Bermejo Basin | -63.00 | -23.50 |
| | | Homahuaca | -65.50 | -23.75 |
| Luciano Dutra INPE | Rain Forest Type Discrimination, Flood Plain Mapping, Calibration Studies, and SAR Model Assessment Using AIRSAR Data: Tapajos Region | Rio Tapajos | -54.80 | -3.05 |
| | | Cachoeira Porteira | -57.05 | -0.65 |
| Tony Freeman Jet Propulsion Lab | JERS-1 Calibration Underflight (Amazon) | Manaus | -60.10 | -3.20 |
| | | Rio Tapajos | -55.20 | -3.70 |
| Ron Greeley Arizona State Univ. | The Relationship Between Radar Backscatter and Aerodynamic Roughness | Cerro Quisharo, Alti | -68.75 | -18.75 |
| Dirk H. Hoekman Wageningen Agricultural Univ. | Remote Sensing of Tropical Rain Forests | Aracuara, Columbia | -72.07 | 0.65 |
| | | Mabura Hill, N, Guyana | -57.90 | 6.70 |
| | | Mabura Hill, S, Guyana | -58.64 | 5.08 |
| | | San Jose del Guaviare | -72.61 | 2.47 |
| Bryan Isacks Cornell University | SIR-C Analysis of Topography and Climate in the Central Andes | Cordillera Blanca, Peru | -77.53 | -9.25 |
| | | Cordillera Real, Bolivia | -68.29 | -16.19 |
| | | Quehcaya Ice Cap | -70.42 | -13.96 |
| | | Potosi | -65.63 | -19.69 |
| Hermann Kux INPE | Forestry and Land Use in Western Amazonia, Acre State Brazil | Sena Maduriera | -68.45 | -9.00 |
| John Kwiatkowski Michigan Technological Univ. | Applications of Polarimetric Radar in Coherent Imaging of Earth and Remote Sensing of Precipitation | Ocean sites en route | | |
| Thuy Le Toan Centre d'Etude Spatiale des Rayonnements | Study of Tropical Rain Forest by SAR Data in French Guiana | Kaw | -52.10 | 4.72 |
| | | St Elie Paracou | -53.03 | 5.28 |
| | | St Laurent | -53.97 | 5.48 |
| John M. Melack Univ. of California, Santa Barbara | Determining the Extent of Inundation on Subtropical Floodplains Beneath Vegetation of Varying Types | Anavilhanas | -60.78 | -2.64 |
| | | Cabaliana | -60.90 | -3.40 |
| | | Pantanal | -57.42 | -19.67 |
| Peter J. Mouginis-Mark Univ. of Hawaii | Radar-Derived Topography of Volcanoes in the Western Galapagos Islands | Galapagos | -91.00 | -1.00 |

| PI Affiliation | Title | Site | approx Lon, Lat | |
|--|--|--|----------------------------|-------------------------|
| Waldir Paradella INPE | Geobotanical Investigation and Lithological Discrimination by AIRSAR Data in the NE of Brazil | Curaca Valley | -39.83 | -9.21 |
| Jack Paris Calstate Fresno | Global Biodiversity: Assessment of Habitat Change and Species Extinctions with Multinamometer SAR | Manaus area | -59.75 | -2.50 |
| Kevin O. Pope GeoEcoArc Research | SIR-C Tropical Wetlands Project | Merida Rio Bravo Rio Hondo | -90.25 -89.03 -88.55 | 20.75 17.52 18.27 |
| Jeffrey E. Richey Univ. of Washington | Land Use, Forest Type and Biomass Assessment Using Polarimetric SAR | Manaus-Fazenda Di. Manaus-Reserva Du. | -59.97 -60.10 | -2.43 -2.93 |
| Davis D. Sentman University of Alaska Fairbanks | Optical Imaging of Cloud-to-Ionosphere Electrical Discharges in Brazil | Thundercloud sites | | |
| David Sheres Stennis Space Center | SAR Measurements of Rain, Waves, Fronts and Eddies | Gulf of Mexico | -89.00 | 27.00 |
| David Skole University of New Hampshire | Assessing Secondary Growth and Carbon Accumulation in Disturbed Tropical Forests Using Airborne Synthetic Aperture Radar | Nova Vida Paradise | -62.79 -63.31 | -10.19 -9.58 |
| Joao Viane Soares INPE | Surface Hydrology of Semiarid Floodplains (Varzeas) in Northeast Brazil (SIR-C/X-SAR) | Bebedouro | -40.28 | -9.08 |
| Vincente Paulo Soares Federal Univ. of Vicosa | Relationship between Radar Image Backscatter and Eucalyptus Stand Characteristics | Minas Gerais | -42.63 | -19.80 |
| John W. Terborgh Duke University | Vegetation Mapping of a Headwater Catchment in the Amazon Basin: Manu National Park, Peru | Manu National Park | -12.05 | -70.35 |
| Jakob J. vanZyl Jet Propulsion Lab | Use of SAR Imagery in Monitoring the Hydrology of Semi-Arid Floodplain Areas in Brazil | Bebedouro | -40.28 | -9.08 |
| Howard A. Zebker Jet Propulsion Lab | Topsar Topographic Mapping Research and Support for the South American DC-8 Deployment | Manaus area Galapagos Islands | -59.75 -91.00 | -2.50 -1.00 |

The Schedule

The following calendars for May and June 1993 show each flight day for the DC-8, indicated by an aircraft icon. The notation *Data Flight* indicates flights where the DC-8 takes off from and returns to the same base, and *Transit to...* indicates takeoff from one base and landing at another, generally with data being acquired en route.

- May 25:** The DC-8 will depart from its home base at Moffett Field, California and will acquire oceanographic data over the Gulf of Mexico before landing at Houston International Airport.
- May 27:** After one day in Houston the aircraft will transit to San Jose, Costa Rica with data acquired en route over the Gulf of Mexico and ecology sites near Merida, Mexico and Rio Hondo and Rio Bravo, Belize.
- May 29:** After one day in San Jose the next flight will be a transit to Guayaquil, Ecuador via the Galapagos Islands. The objective will be to map all of Isla Fernandina and Isla Isabela in TOPSAR mode, as indicated on the attached map, but as currently planned this flight is near the duration limit for a one day DC-8 flight and a slightly smaller data set may be acquired.
- May 31:** During this flight from Guayaquil the sites at Aracuara and San Jose del Guaviare in Colombia will be imaged, as well as the set of lines called the "volcano transect." Not yet planned in detail, these lines will image a number of Andean volcanoes along a track intended to cover as many individual sites as possible.
- June 2:** During the transit to Santa Cruz, Bolivia TOPSAR mode data will be acquired at Cordillera Blanca and the Quelccaya Ice Cap in the Peruvian Andes, and the site at Manu National Park will also be imaged.
- June 4:** Data sites for this flight from Santa Cruz include Cordillera Real and Potosi, which will be imaged in TOPSAR mode, and Cerro Quisharo near the Chilean border.
- June 6:** Flying south into Argentina, AIRSAR will collect data at the hydrology sites at Bermejo Basin and Homahuaca, then the rest of the flight will be dedicated to Dave Sentman's lightning imaging experiment. Since the lightning experiment is weather dependent, the scheduling for this flight may be modified in real time to match the opportunities that arise.
- June 8:** This transit flight to Recife, Brazil will cover the Pantanal site in Brazil and the SIR-C/X-SAR "super site" at Bebedouro.
- June 11:** This flight will be second of four to overfly Bebedouro, the intent being to acquire data under different ground conditions, primarily soil moisture. For that reason the date of this and the following flight may be adjusted slightly according to weather conditions. Also covered on this day will be the site at Minas Gerais.
- June 12:** During this flight data will be acquired at the Curaca Valley site as well as Bebedouro.
- June 15:** This transit flight into Manaus provides one last opportunity to image Bebedouro, and in transit the site at Rio Tapajos will be covered in both SAR and TOPSAR modes.
- June 17:** This will be the first of two flights over the Manaus area, with the plan being to acquire data along tracks matching the ground swaths of both the JERS-1 and Shuttle Imaging Radar experiments. The dates of this and the following flight may be adjusted to accommodate the lightning imaging experiment.










June 19: This flight will be divided between the acquisition of data along certain specific tracks in the Manaus area for Howard Zebker's forest investigation, and at targets of opportunity for the lightning imaging experiment. Due to the weather-dependent nature of the lightning experiment, the flight may occur on a different day or be swapped with the preceding flight.

June 21: During this flight data will be acquired at the SIR-C/X-SAR site at Sena Madureira as well as at Paradise and Nova Vida. Finally, data lines will be flown at the Rio Tapajos site to match an overflight of the JERS-1 satellite which will be imaging the region on that day.

June 24: The transit to San Juan, Puerto Rico will provide coverage at the Cachoreira Porteira site northeast of Manaus, Kaw, Paracou and St. Laurent along the coast of French Guiana, and Mabura Hill in Guyana.

June 26: This last flight of the deployment will be a transit back to Moffett and no AIRSAR data will be acquired.

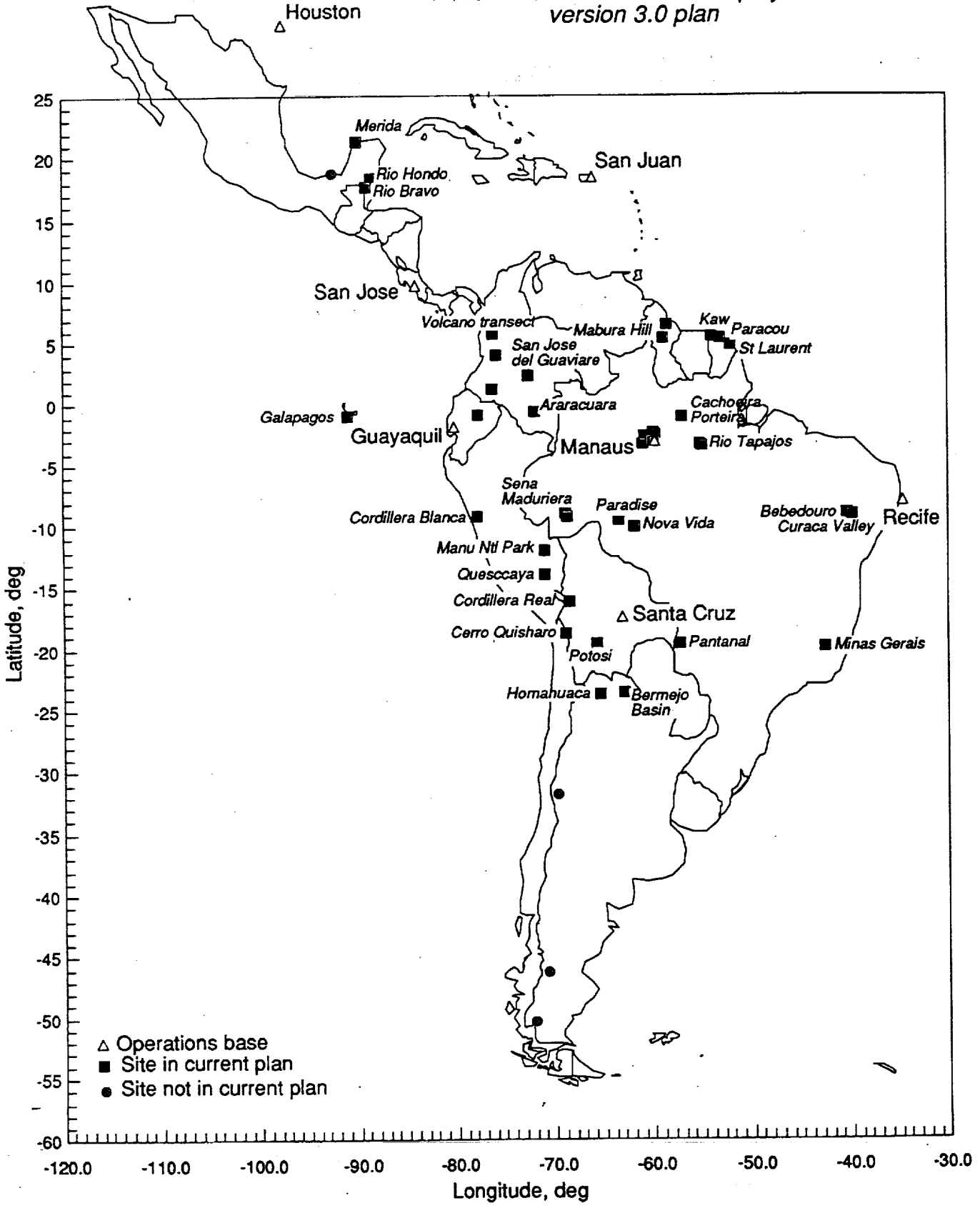
May 1993

| Sunday | Monday | Tuesday | Wednesday | Thursday | Friday | Saturday |
|--------|---|---|--|---|---|--|
| | | | | | | |
| 2 | 3 Engineering flight | 4 | 5 | 6 Engineering flight | 7  | 8 |
| 9 | 10  | 11 Calibration flight Rosamond Fort Irwin Crystal Spring | 12 Data flight Jornada Sevilleta | 13 | 14 | 15 |
| 16 | 17 | 18  | 19  | 20  | 21 | 22 |
| 23 | 24 Data Flight Colombian volcanics San Jose del Guaviare Araracuara | 25  | 26 | 27 Transit to San Jose Gulf of Mexico Merida Rio Hondo Rio Bravo | 28  | 29 Transit to Guayaquil Galapagos  |
| 30 | 31  | | | | | |

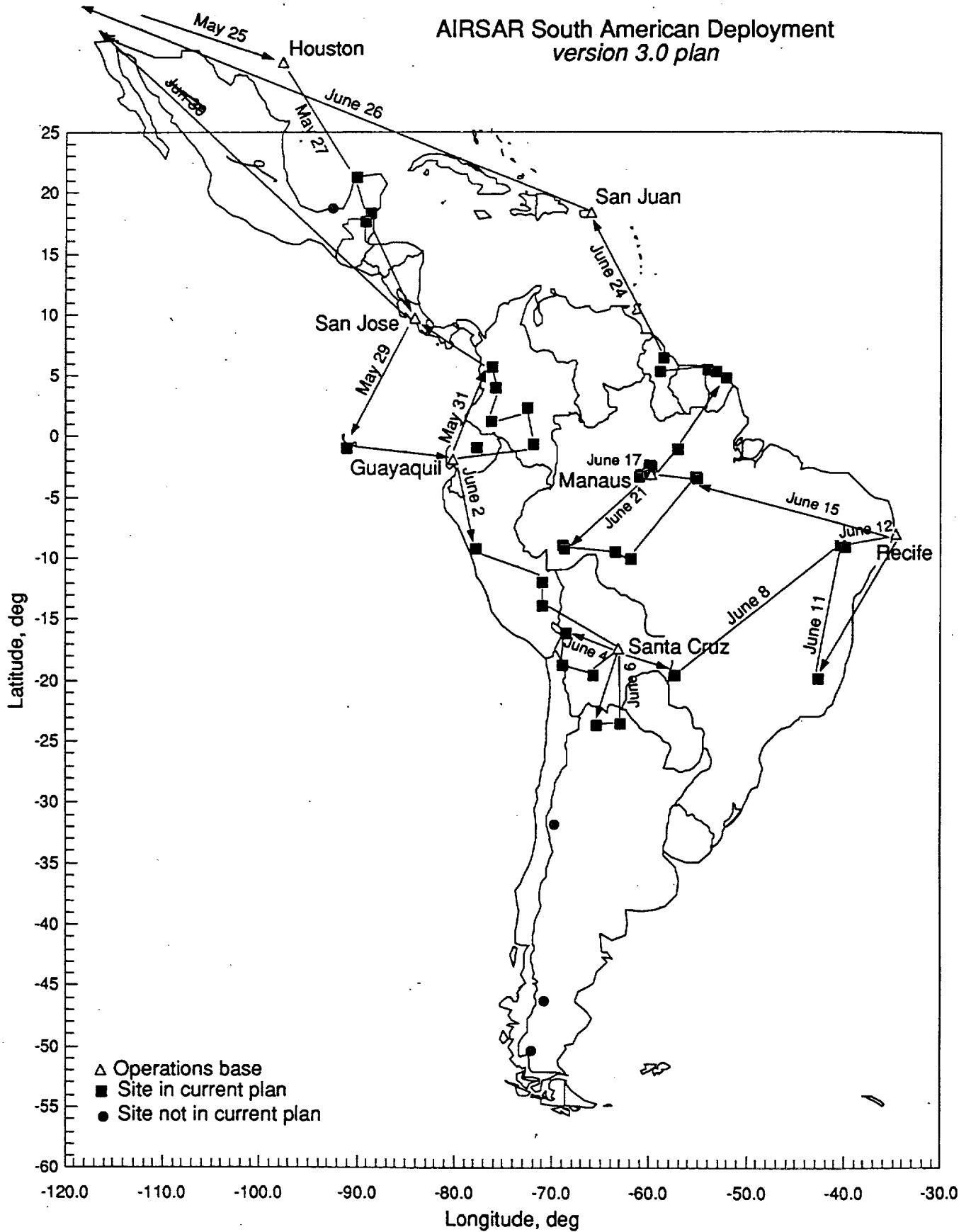
June 1993

| Sunday | Monday | Tuesday | Wednesday | Thursday | Friday | Saturday |
|---|--|---|---|---|--|---|
| | | | Transit to Santa Cruz Cordillera Blanca Manu National Park Quelccaya Ice Cap | | Data Flight Cordillera Real Cerro Quisharo Potosi | |
| | | 1 | 2 | 3 | 4 | 5 |
| Data Flight Bermejo Basin Homahuaca (thunderstorm oppty) | | Transit to Recife Pantanal Bebedouro | | | Data Flight Minas Gerais Bebedouro | Data Flight Curaca Valley Bebedouro |
| 6 | | 8 | 9 | 10 | 11 | 12 |
| | | Transit to Manaus Bebedouro Rio Tapajos | | Data Flight Manaus sites | | Data flight Manaus sites thunderstorm oppty |
| 13 | | 15 | 16 | 17 | 18 | 19 |
| | Data flight Sena Madureira Paradise Nova Vida Rio Tapajos (JERS) | | | Transit to San Juan Cachoeira Porteira Kaw Paracou St. Laurent Mabura Hill | | Transit to Mofatt |
| 20 | 21 | 22 | 23 | 24 | 25 | 26 |
| | | | | | | |
| 27 | 28 | 29 | 30 | | | |

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version 3.0 plan



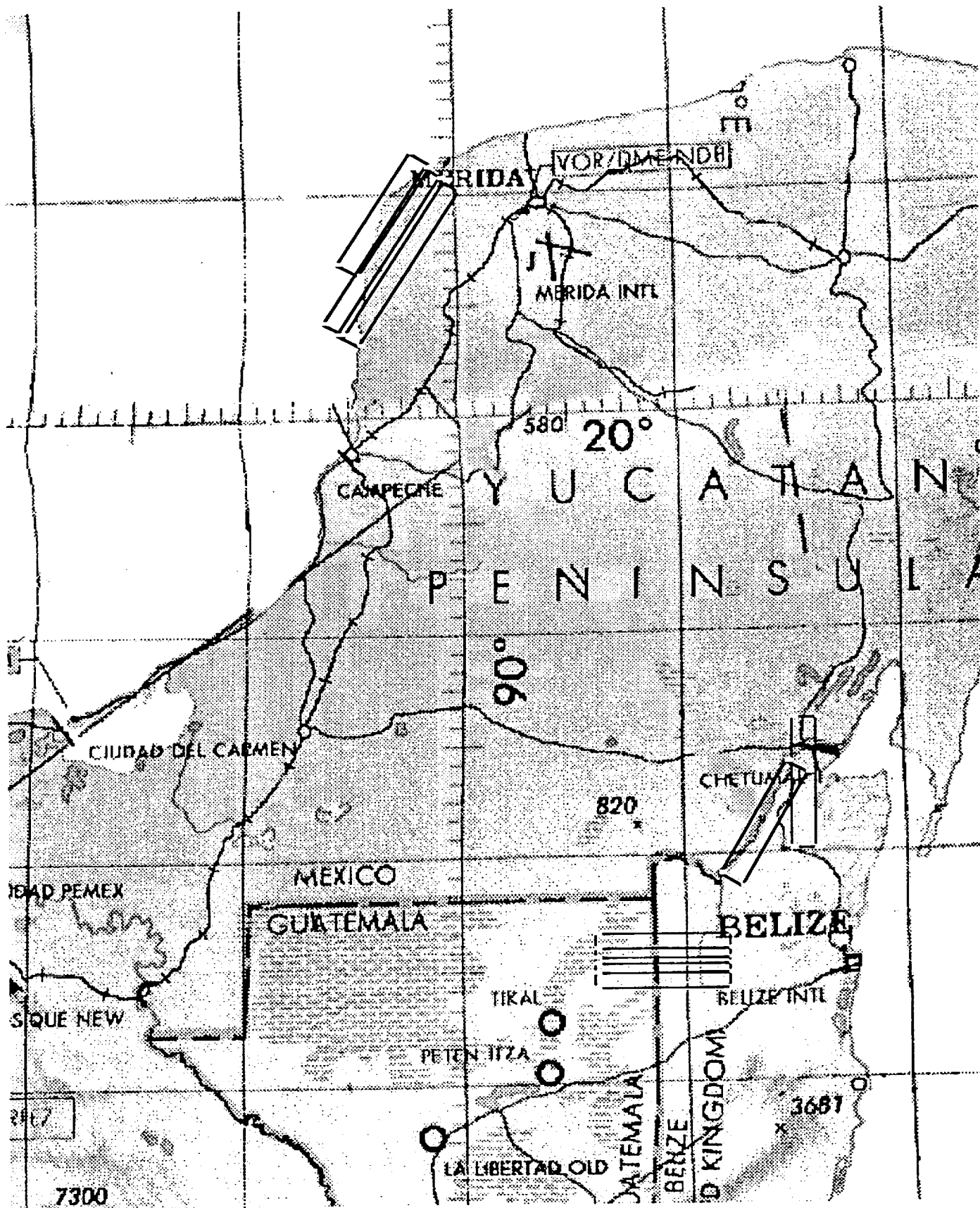
AIRSAR South American Deployment version 3.0 plan

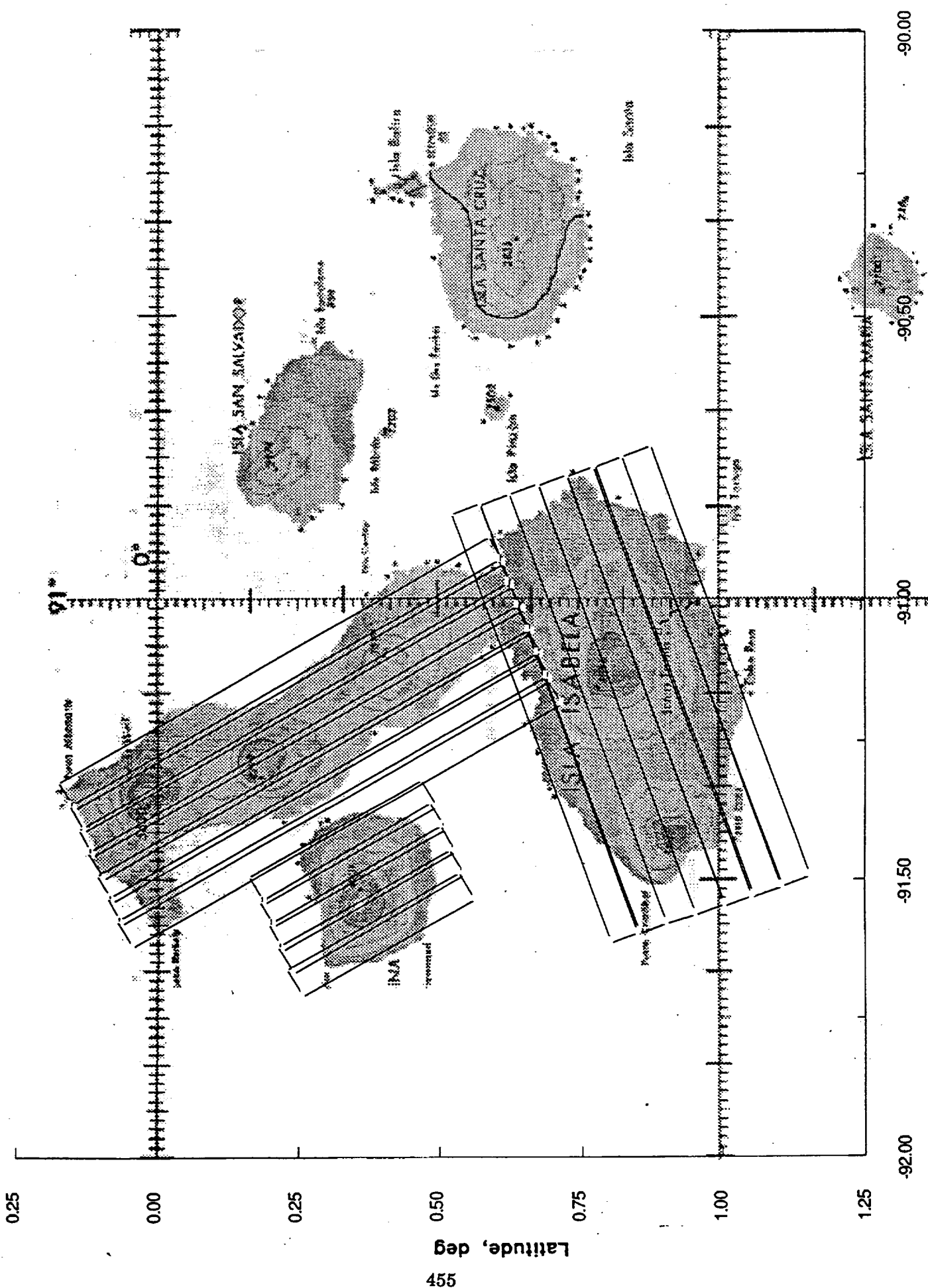


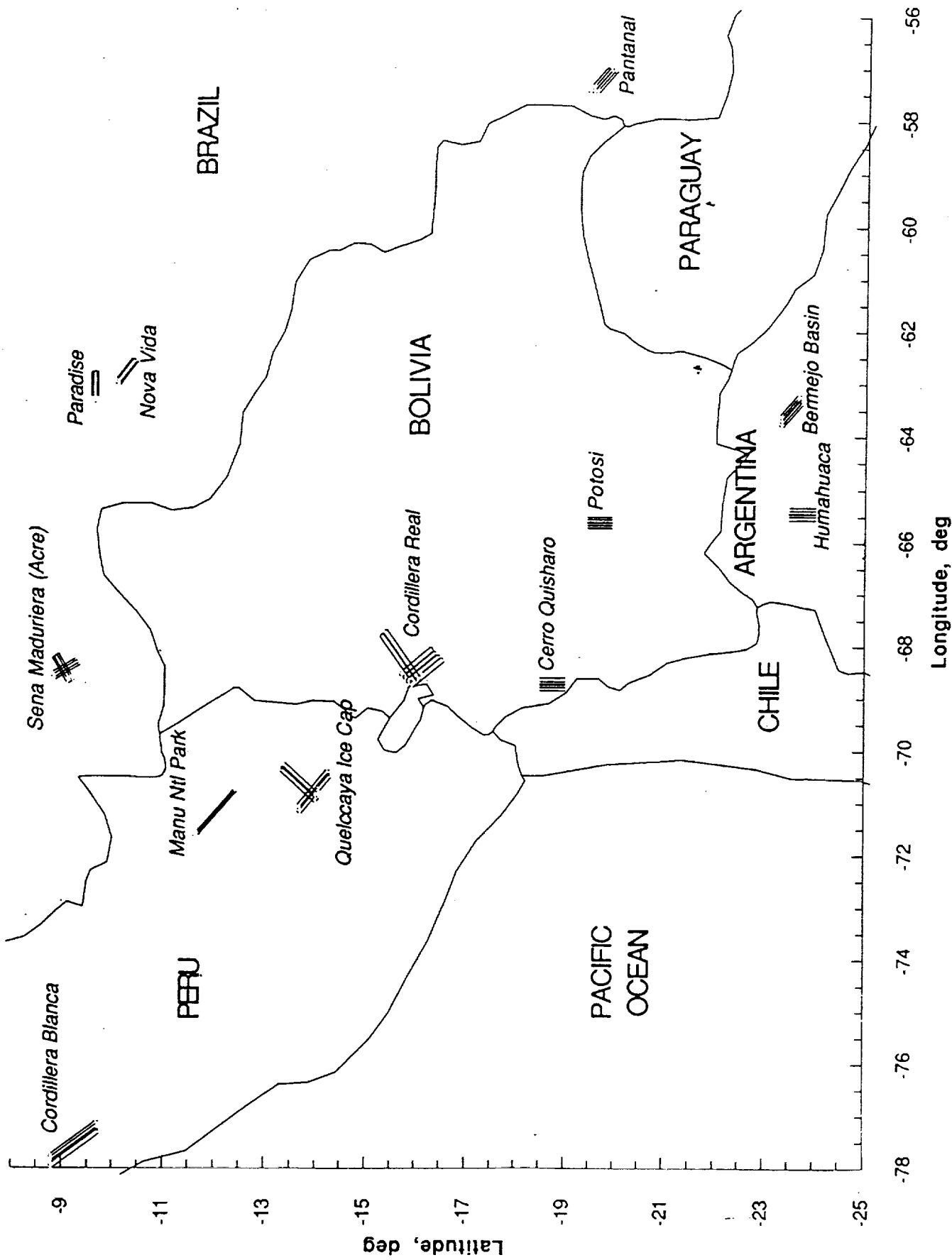
South America '93

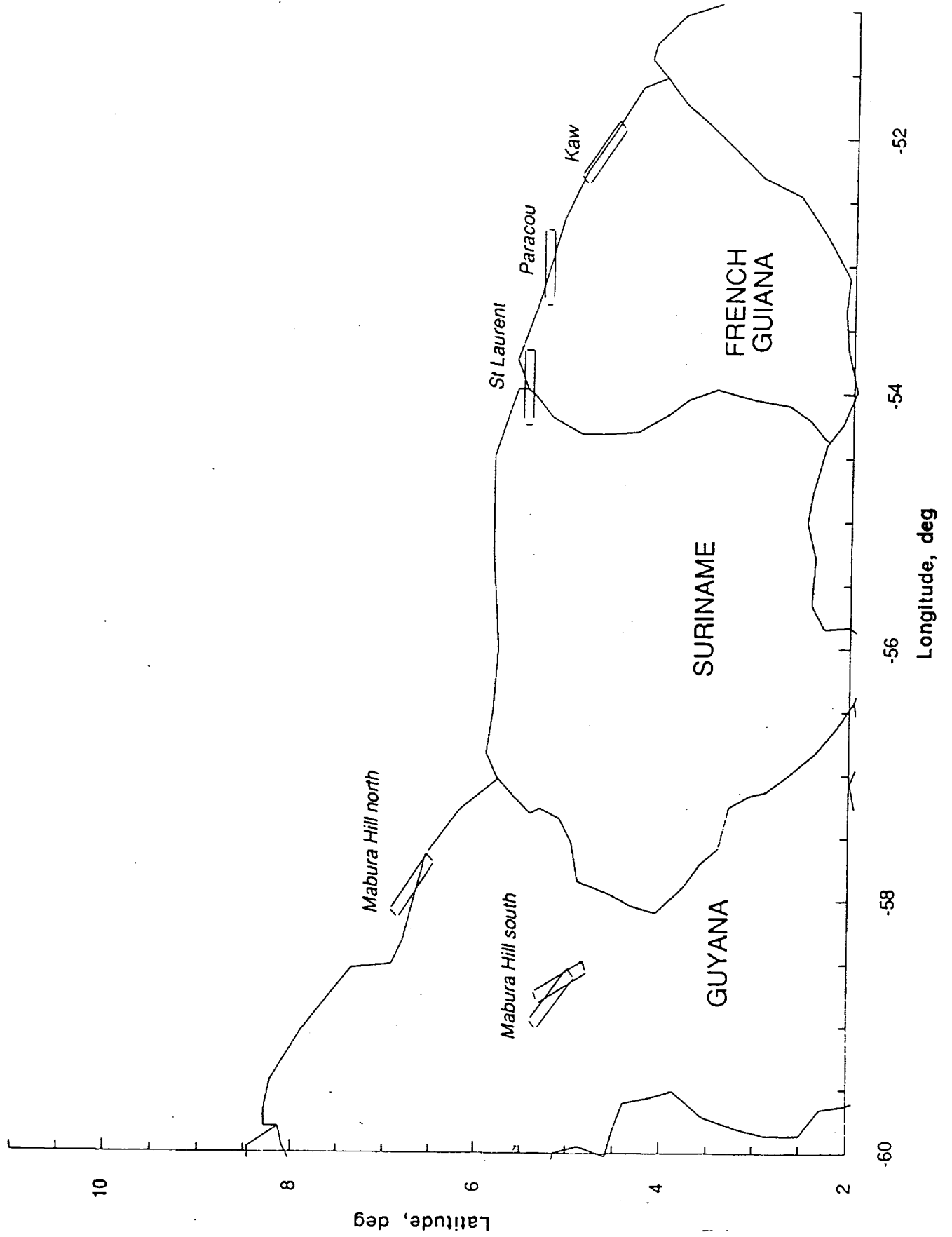
version 3.0

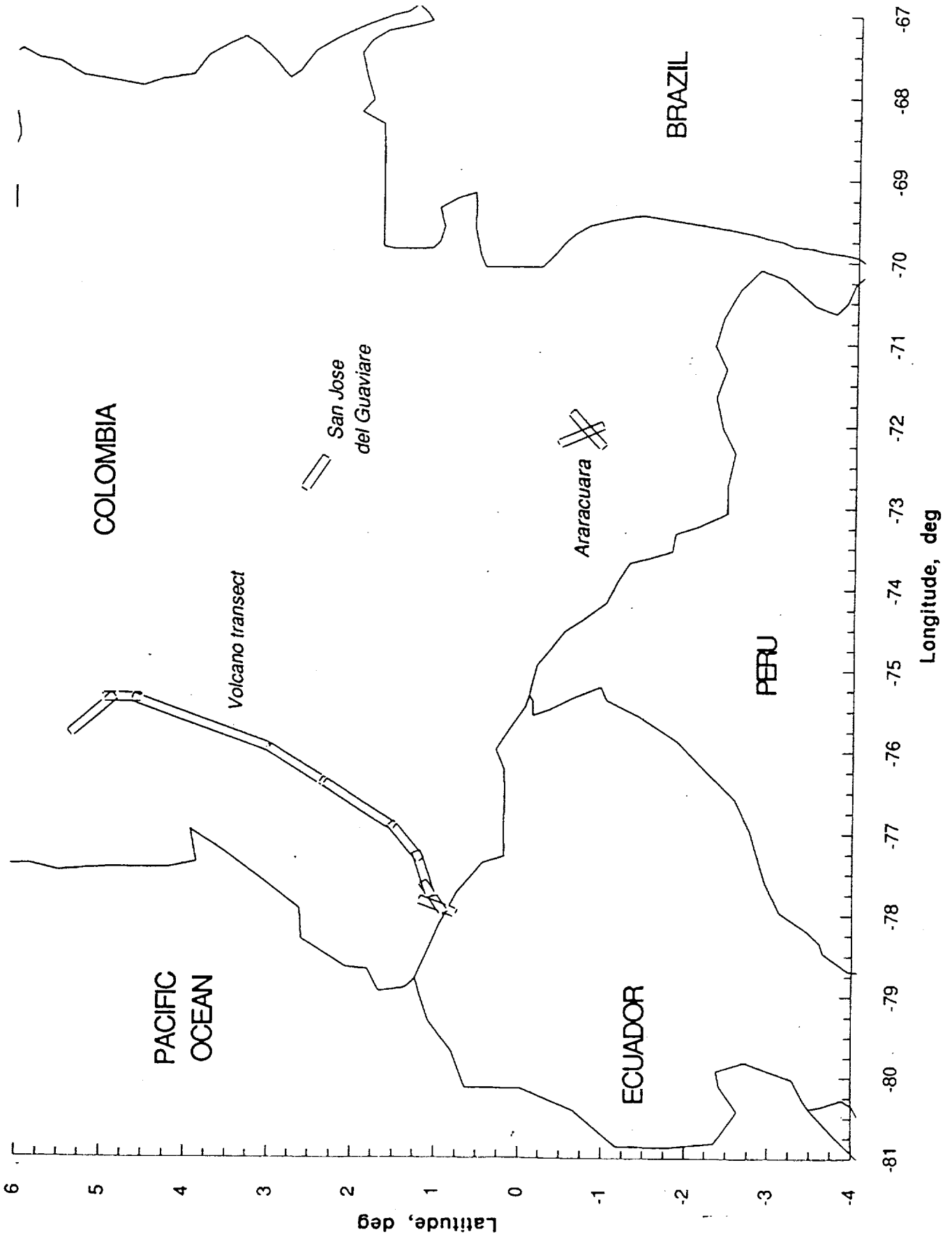
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|--------|--------------------|------|-------------------|------------|-------------------|-------|------|------|--|--|--|--|--|--|--|--|--|--|--|--|
| | d | m | d | m | to | | | | | | | | | | | | | | | |
| 25-May | 37 | 24.9 | -122 | 2.8 | Moffett | | | | | | | | | | | | | | | |
| | 27 | 55.0 | -93 | 35.0 | Gulf of Mexico | 3.4 | 2.0 | | | | | | | | | | | | | |
| | 29 | 27.0 | -95 | 12.6 | Houston | 0.3 | | | | | | | | | | | | | | |
| | | | | | Block time | 0.8 | | 6.45 | | | | | | | | | | | | |
| 27-May | 29 | 27.0 | -95 | 12.6 | Houston | | | | | | | | | | | | | | | |
| | 27 | 55.0 | -93 | 35.0 | Gulf of Mexico | 0.3 | 1.0 | | | | | | | | | | | | | |
| | 20 | 45.0 | -90 | 15.0 | Merida | 1.0 | 0.8 | | | | | | | | | | | | | |
| | 18 | 16.2 | -88 | 33.0 | Rio Hondo | 0.4 | 0.5 | | | | | | | | | | | | | |
| | 17 | 31.2 | -89 | 1.8 | Rio Bravo | 0.1 | 0.5 | | | | | | | | | | | | | |
| | 9 | 33.6 | -84 | 3.0 | San Jose | 1.2 | | | | | | | | | | | | | | |
| | | | | Block time | 0.8 | | 6.57 | | | | | | | | | | | | | |
| 29-May | 9 | 33.6 | -84 | 3.0 | San Jose | | | | | | | | | | | | | | | |
| | -1 | 0.0 | -91 | 0.0 | Galapagos | 1.7 | 4.0 | | | | | | | | | | | | | |
| | -2 | 6.0 | -79 | 30.0 | Guayaquil | 1.5 | | | | | | | | | | | | | | |
| | | | | Block time | 0.8 | | 7.97 | | | | | | | | | | | | | |
| 31-May | -2 | 6.0 | -79 | 30.0 | Guayaquil | | | | | | | | | | | | | | | |
| | 0 | 58.8 | -77 | 54.9 | Mayasquer volcano | 0.5 | 0.3 | | | | | | | | | | | | | |
| | 1 | 1.8 | -77 | 48.3 | Cumbal volcano | 0.0 | 0.3 | | | | | | | | | | | | | |
| | 1 | 9.0 | -77 | 30.9 | Azurfal volcano | 0.0 | 0.3 | | | | | | | | | | | | | |
| | 1 | 22.2 | -77 | 6.9 | Galeras volcano | 0.1 | 0.3 | | | | | | | | | | | | | |
| | 1 | 56.7 | -76 | 39.3 | Dona Juana vol. | 0.1 | 0.3 | | | | | | | | | | | | | |
| | 2 | 41.1 | -76 | 10.8 | Huila volcano | 0.1 | 0.3 | | | | | | | | | | | | | |
| | 3 | 49.5 | -75 | 40.5 | Tolima volcano | 0.2 | 0.3 | | | | | | | | | | | | | |
| | 4 | 45.9 | -75 | 22.2 | Ruiz volcano | 0.1 | 0.3 | | | | | | | | | | | | | |
| | 5 | 6.9 | -75 | 34.6 | Herveo volcano | 0.1 | 0.3 | | | | | | | | | | | | | |
| | 2 | 28.2 | -72 | 36.6 | San Jose del Gu. | 0.5 | 0.5 | | | | | | | | | | | | | |
| | 0 | 39.0 | -72 | 4.2 | Aracuara | 0.3 | 0.5 | | | | | | | | | | | | | |
| | -2 | 6.0 | -79 | 30.0 | Guyaquil | 1.1 | | | | | | | | | | | | | | |
| | | | | Block time | 0.8 | | 6.99 | | | | | | | | | | | | | |
| 2-Jun | -2 | 6.0 | -79 | 30.0 | Guayaquil | | | | | | | | | | | | | | | |
| | -9 | 15.0 | -77 | 32.0 | Cordillera Blanca | 1.0 | 1.3 | | | | | | | | | | | | | |
| | -12 | 2.0 | -71 | 12.0 | Manu Ntl Park | 0.9 | 1.2 | | | | | | | | | | | | | |
| | -13 | 57.5 | -70 | 47.5 | Queccaya Ice Cap | 0.3 | 1.2 | | | | | | | | | | | | | |
| | -17 | 28.8 | -63 | 6.0 | Santa Cruz | 1.1 | | | | | | | | | | | | | | |
| | | | | Block time | 0.8 | | 7.59 | | | | | | | | | | | | | |
| 4-Jun | -17 | 28.8 | -63 | 6.0 | Santa Cruz | | | | | | | | | | | | | | | |
| | -16 | 11.5 | -68 | 16.5 | Cordillera Real | 0.7 | 1.5 | | | | | | | | | | | | | |
| | -18 | 45.0 | -68 | 45.0 | Cerro Quisharo | 0.3 | 1.0 | | | | | | | | | | | | | |
| | -19 | 41.5 | -65 | 38.0 | Potosi | 0.4 | 0.5 | | | | | | | | | | | | | |
| | -17 | 28.8 | -63 | 6.0 | Santa Cruz | 0.4 | | | | | | | | | | | | | | |
| | | | | Block time | 0.8 | | 5.63 | | | | | | | | | | | | | |
| 6-Jun | -17 | 28.8 | -63 | 6.0 | Santa Cruz | | | | | | | | | | | | | | | |
| | -23 | 30.0 | -63 | 0.0 | Bermejo Basin | 0.8 | 0.5 | | | | | | | | | | | | | |
| | -23 | 45.0 | -65 | 30.0 | Homahuaca | 0.3 | 0.5 | | | | | | | | | | | | | |
| | -17 | 28.8 | -63 | 6.0 | Thunderstorms/Li. | 0.9 | 4.0 | | | | | | | | | | | | | |
| | -17 | 28.8 | -63 | 6.0 | Santa Cruz | 0.0 | | | | | | | | | | | | | | |
| | | | | Block time | 0.8 | | 7.75 | | | | | | | | | | | | | |
| 8-Jun | -17 | 28.8 | -63 | 6.0 | Santa Cruz | | | | | | | | | | | | | | | |
| | -19 | 40.2 | -57 | 15.0 | Pantanal | 0.8 | 0.0 | | | | | | | | | | | | | |
| | -19 | 40.2 | -57 | 15.0 | Pantanal | 0.0 | 2.0 | | | | | | | | | | | | | |
| | -9 | 4.8 | -40 | 16.8 | Bebedouro | 2.6 | 1.0 | | | | | | | | | | | | | |
| | -8 | 1.8 | -34 | 32.0 | Recife | 0.8 | | | | | | | | | | | | | | |
| | | | | Block time | 0.8 | | 7.92 | | | | | | | | | | | | | |

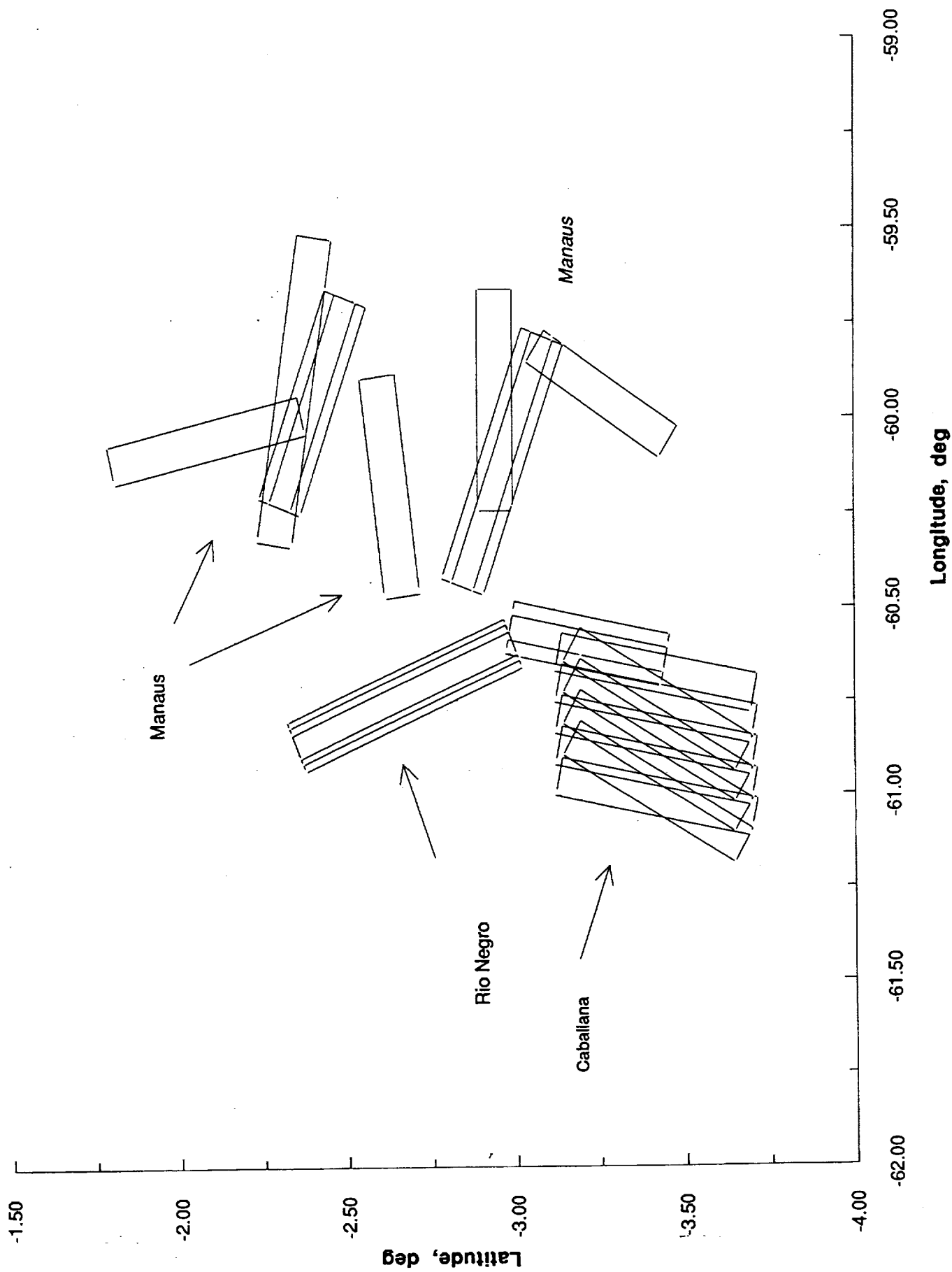


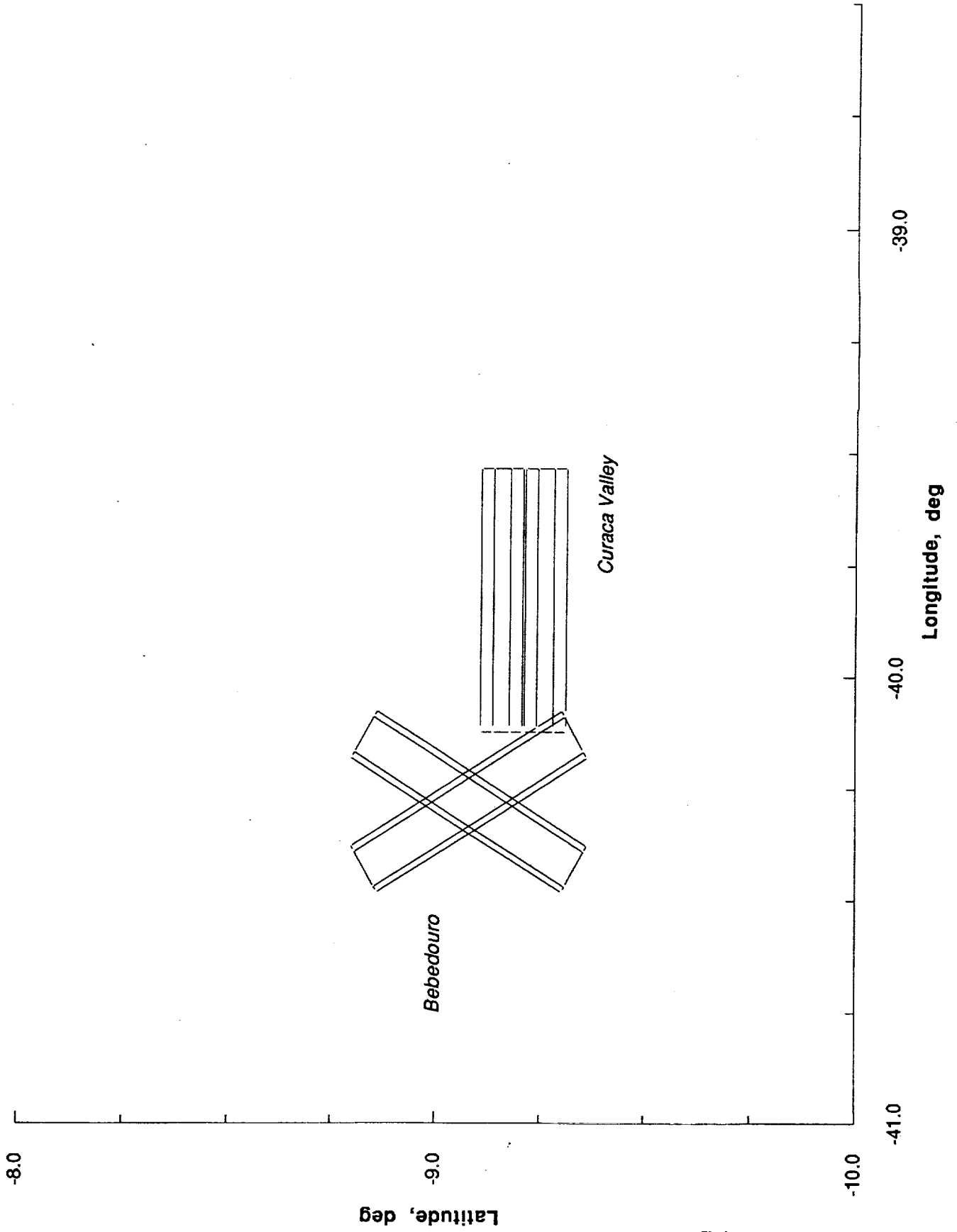


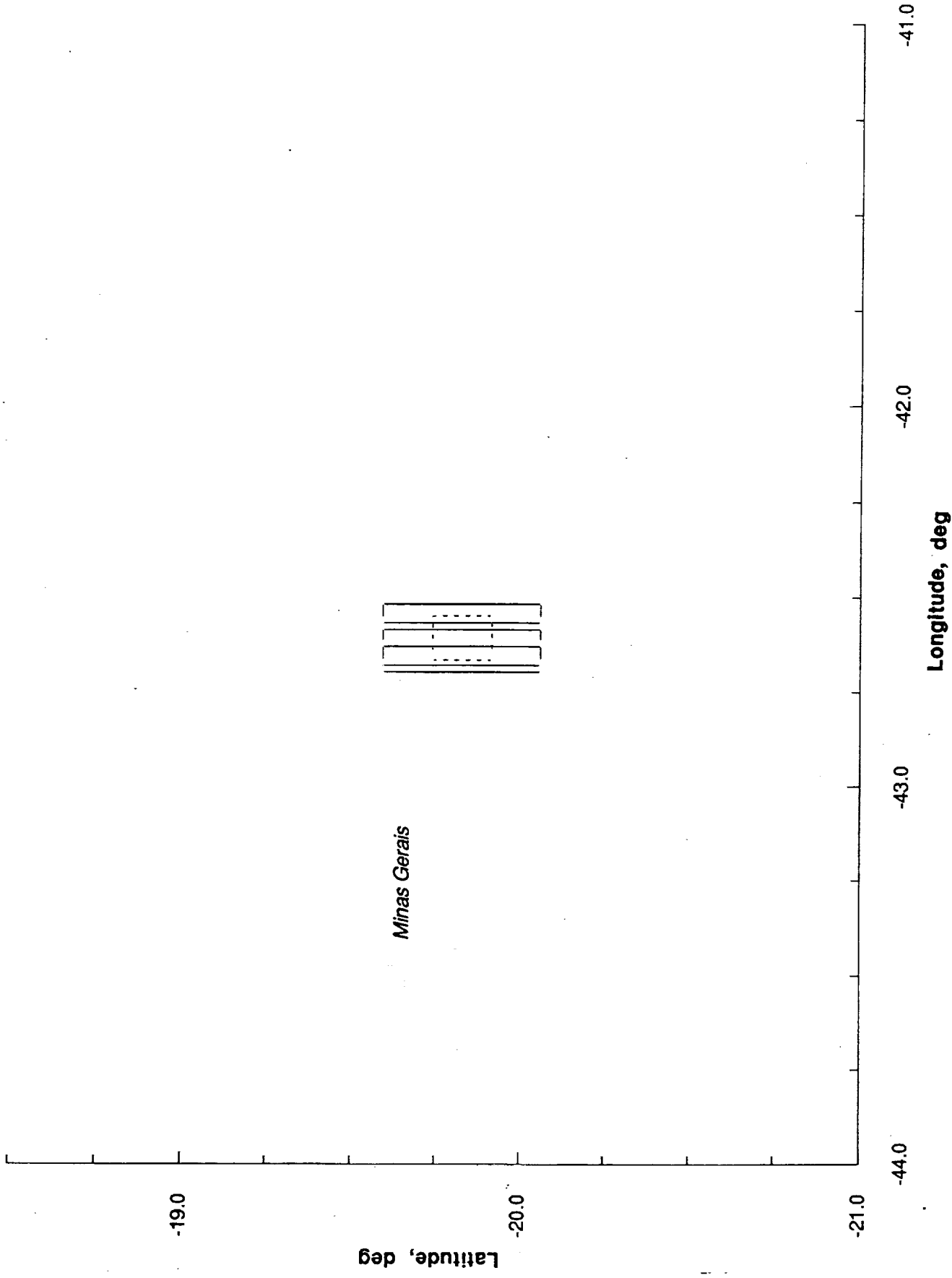








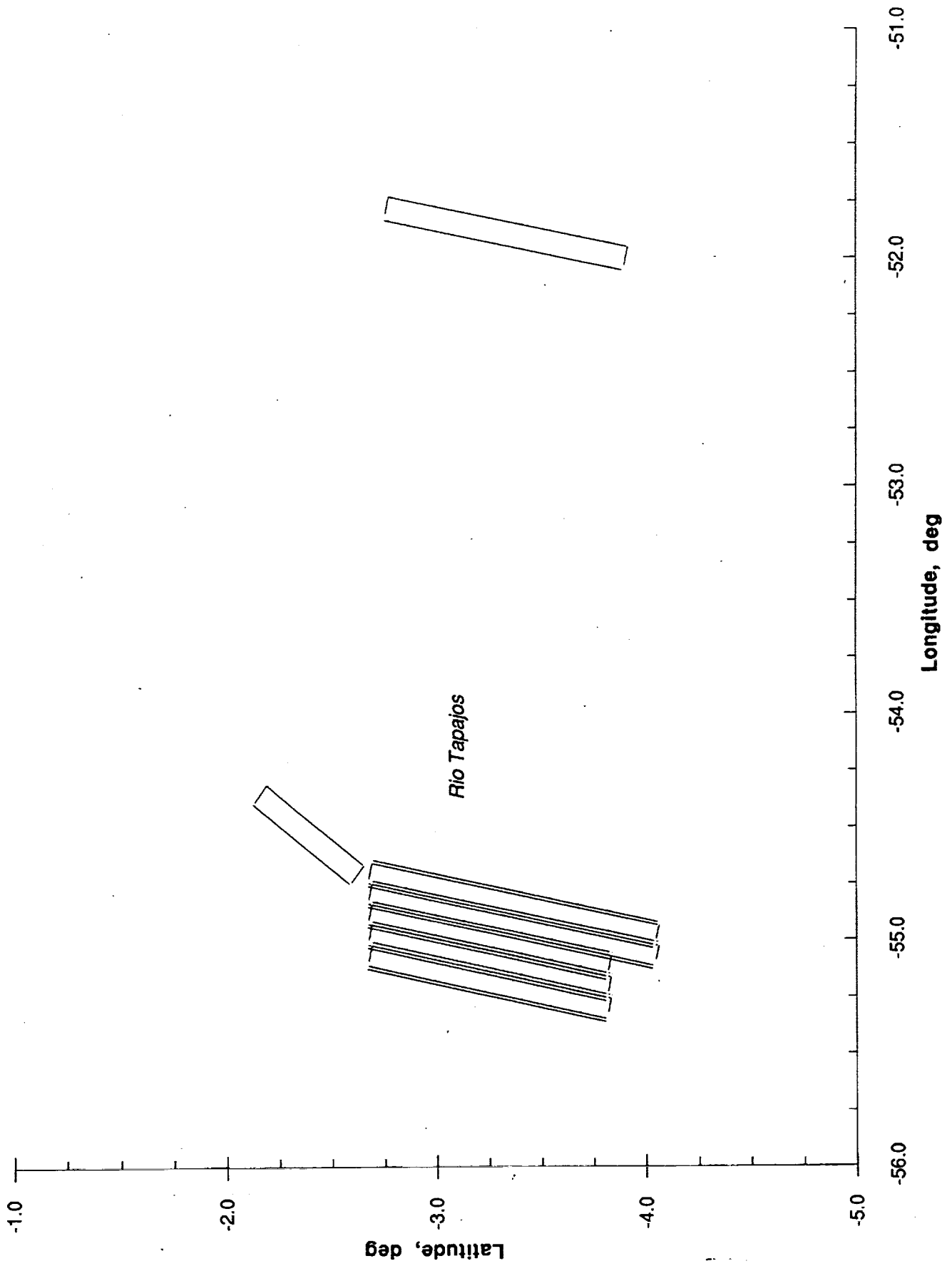


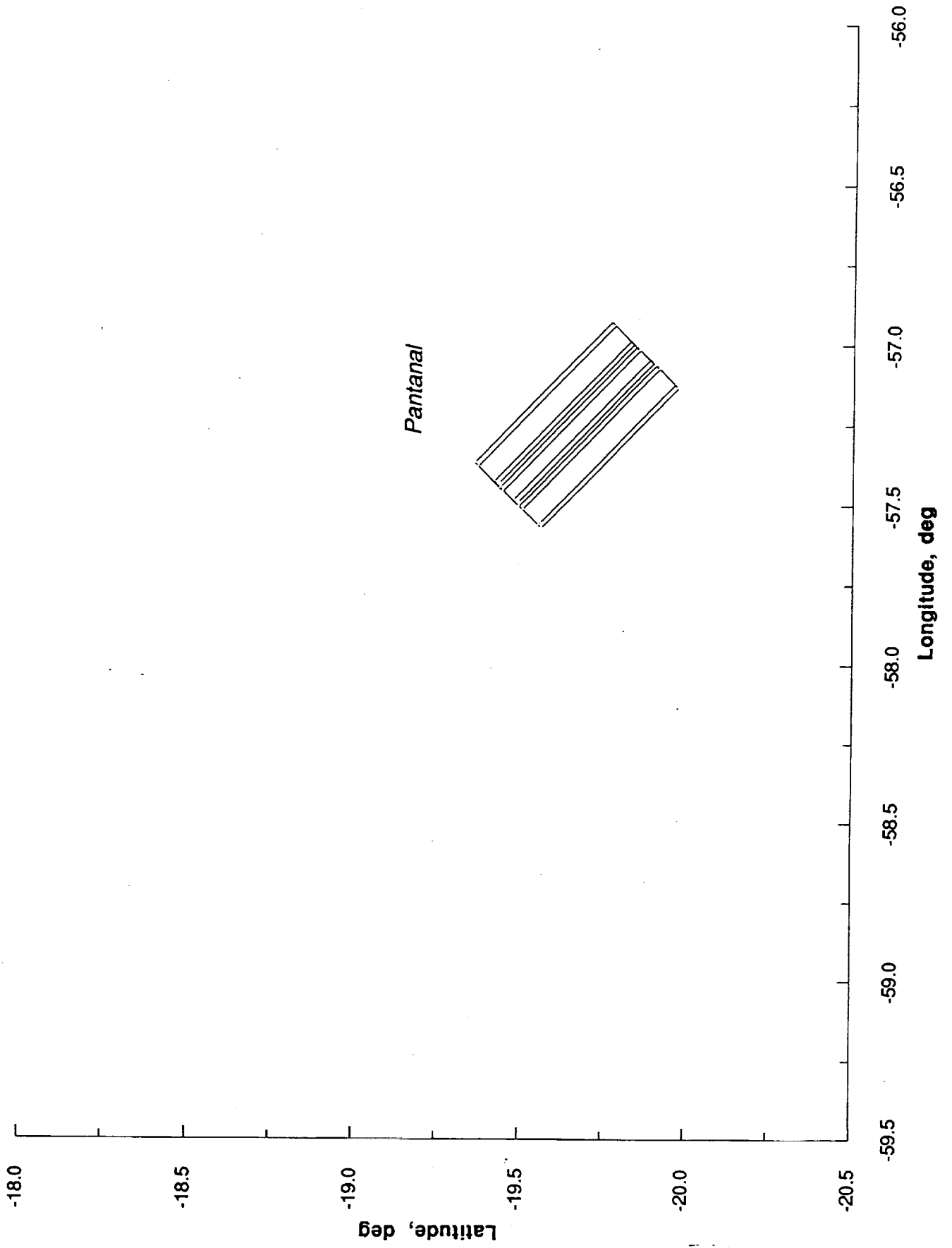


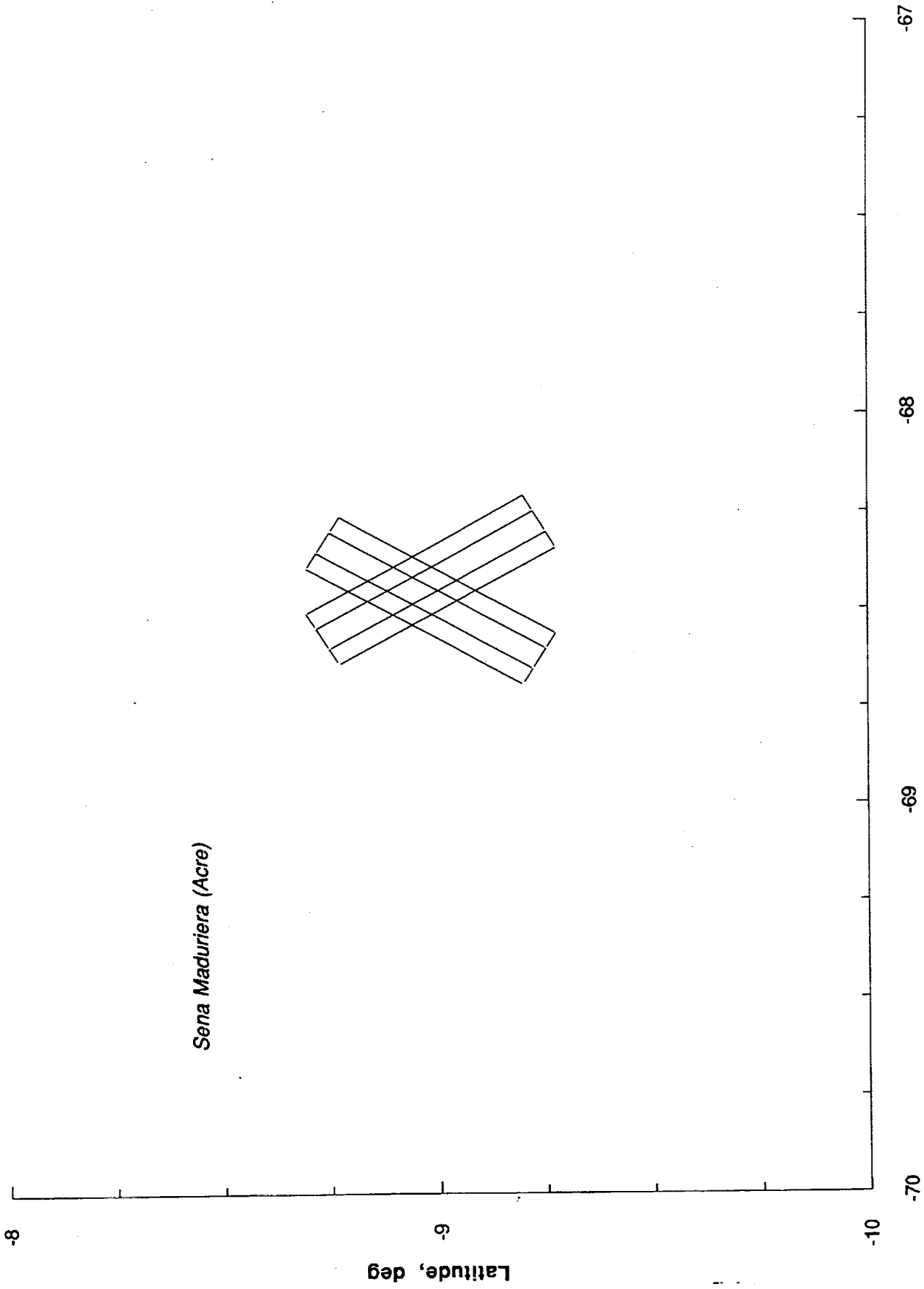
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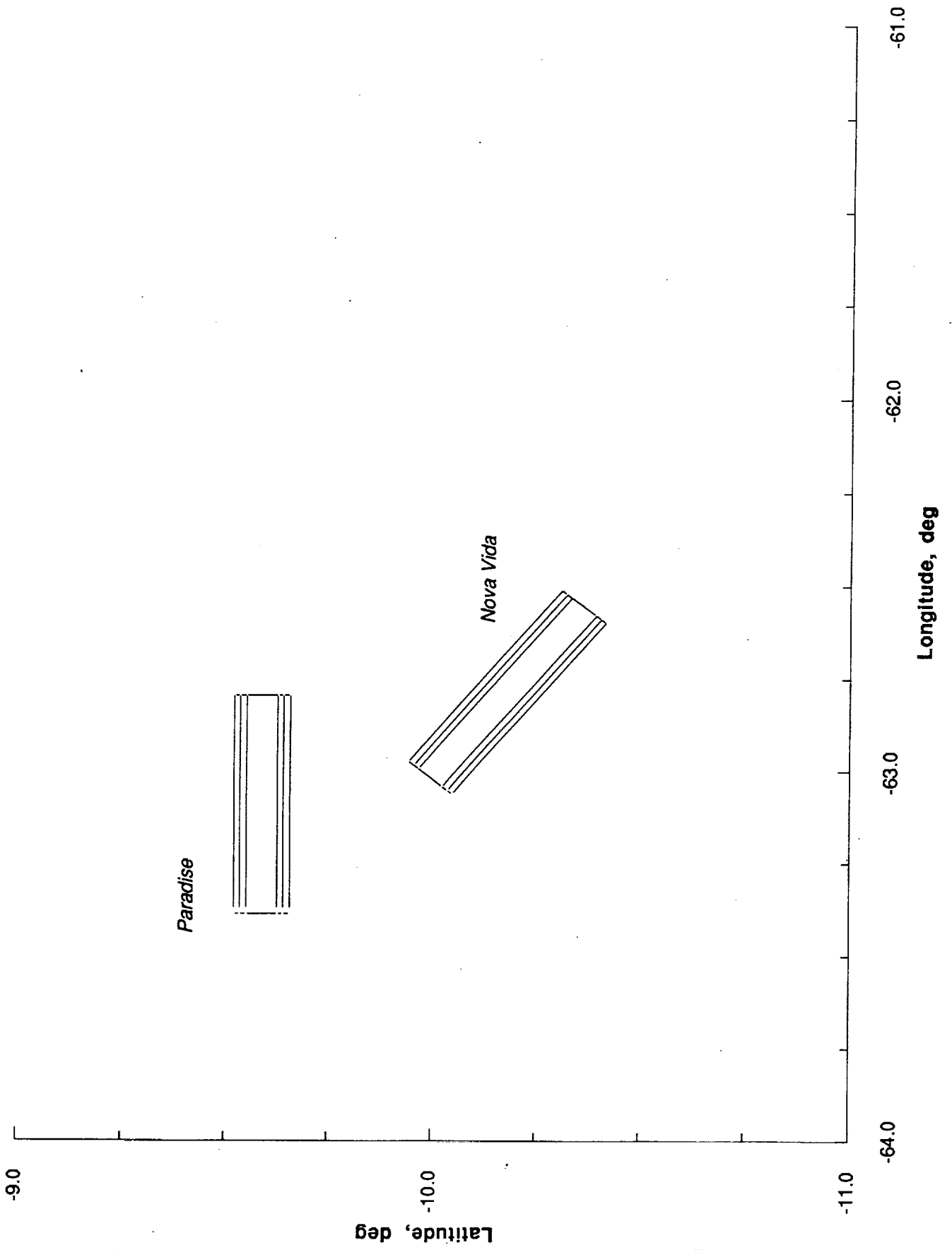
Longitude, deg

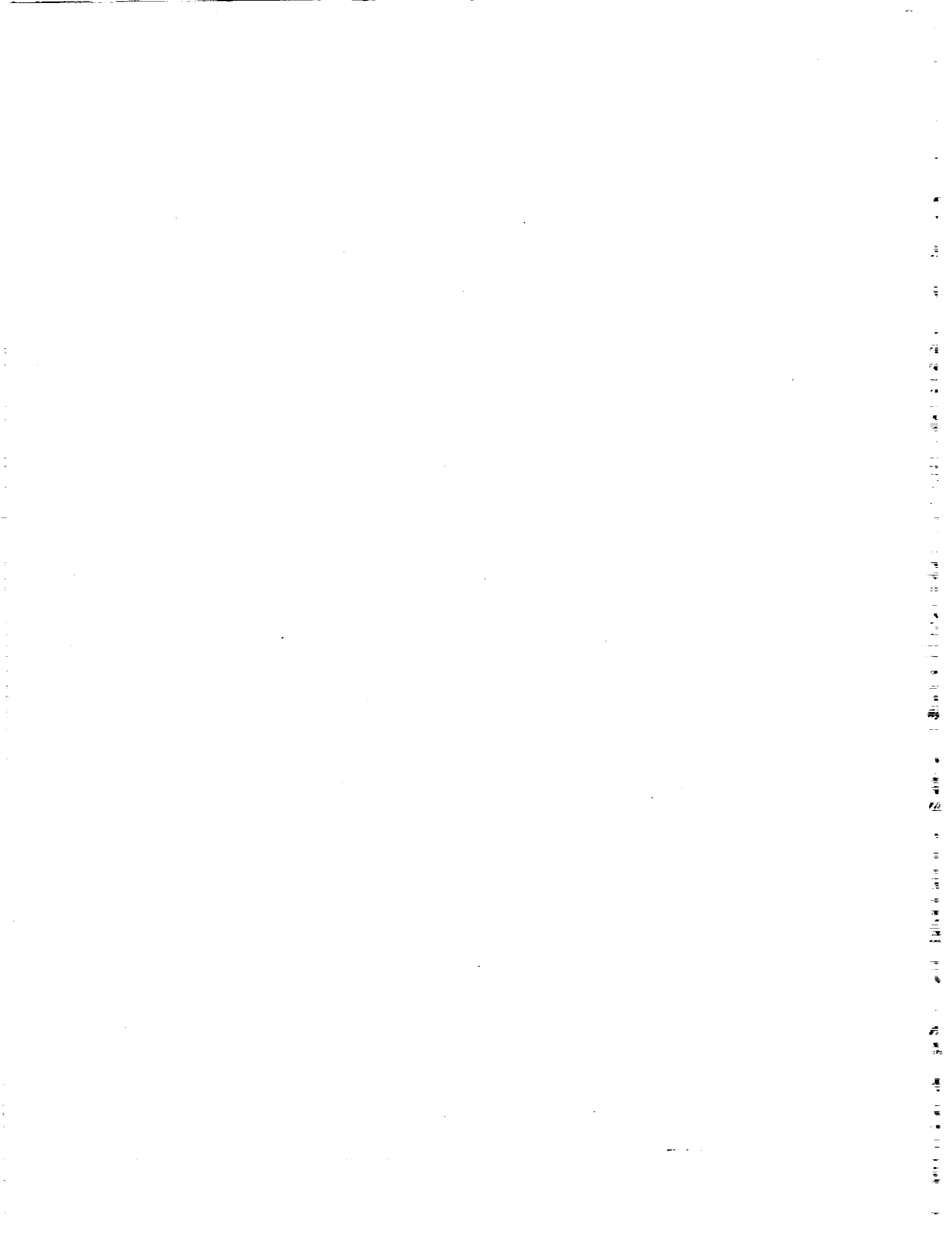
Minas Gerais











TECHNICAL REPORT STANDARD TITLE PAGE

| | | |
|--|--|---|
| 1. Report No. 93-16 | 2. Government Accession No. | 3. Recipient's Catalog No. |
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