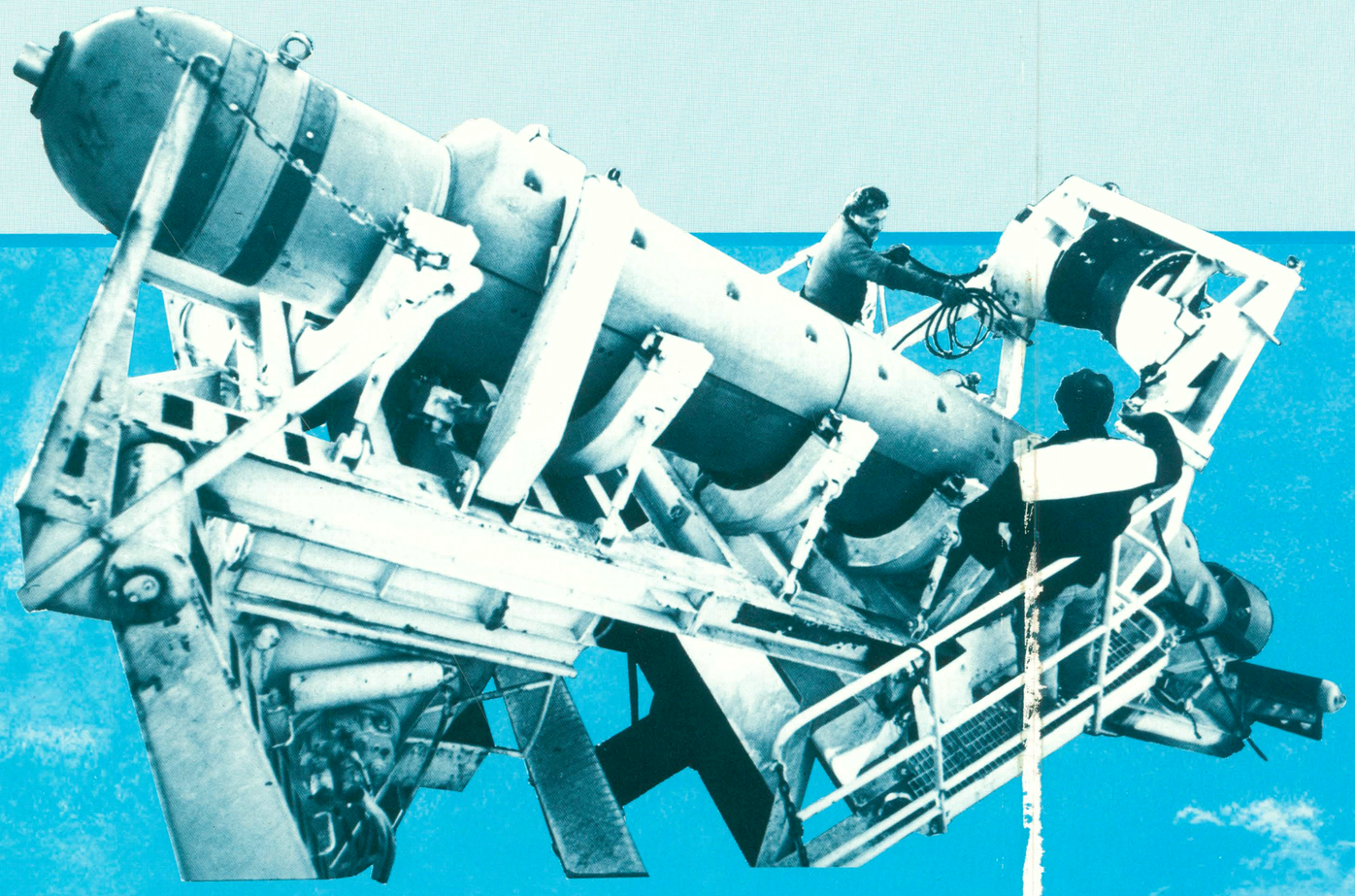
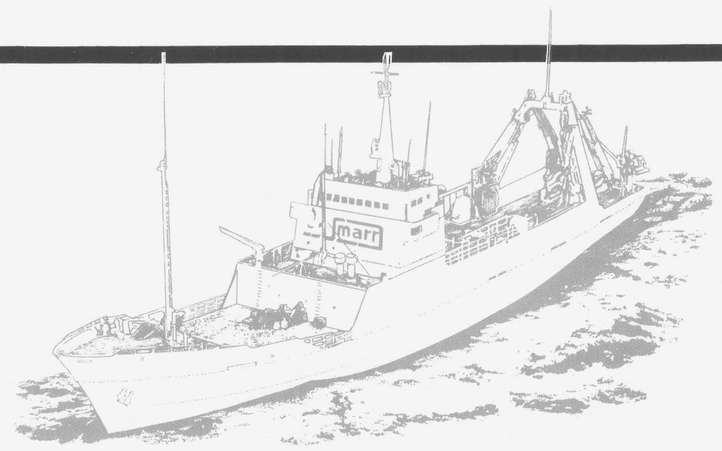
Atlas of the Exclusive Economic Zone, Western Conterminous United States



U.S. Geological Survey
Miscellaneous Investigations Series I-1792

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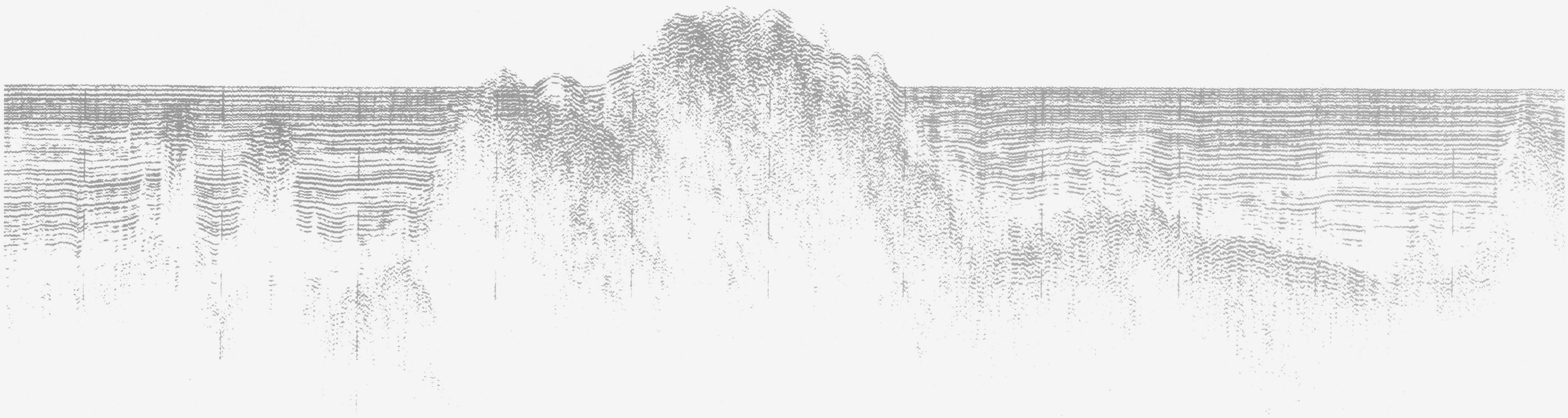


By EEZ SCAN 84 Scientific Staff

U.S. Geological Survey Miscellaneous Investigations Series I-1792

DEPARTMENT OF THE INTERIOR
DONALD PAUL HODEL, Secretary

U.S. GEOLOGICAL SURVEY
Dallas L. Peck, Director



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COVER: Launching the GLORIA instrument from the stern of *Farnella* (photograph by Henry Chezar, U.S. Geological Survey). The sonar mosaic is the region of Taney Seamounts, west of San Francisco, Calif.

FOREWORD

Dallas L. Peck
Director, U.S. Geological Survey

An act of Congress in 1879 established the U.S. Geological Survey (USGS) as a scientific research organization and charged it to conduct an "examination of the geological structure, mineral resources, and products of the national domain." Not until 1962, however, were these examinations extended into the marine realm, when Congress first appropriated funds for offshore investigations by the USGS. During the late 1960's and 1970's, offshore geologic surveys conducted by the USGS rapidly expanded as the result of national and international events such as increased domestic oil and gas exploration and the oil embargo by the Organization of Petroleum Exporting Countries.

On March 10, 1983, President Reagan proclaimed that the ocean area out to 200 nautical miles off the coast of the United States and its island territories was the Exclusive Economic Zone (EEZ) of this Nation. The proclamation increased the area of offshore Federal lands to approximately 3.4 million square nautical miles, an area about 130 percent larger than the total onshore area of the United States. As noted by the National Advisory Committee on Oceans and Atmosphere, considering the rate of depletion of the Earth's natural resources on land and the potential that the oceans are believed to have for addition to our resource base, the significance of the EEZ to the future of our country may well be greater than that of the Louisiana Purchase of 1803. That act (during the Presidency of Thomas Jefferson) doubled the size of our country and brought with it a vast territorial and resource base on which the United States grew during the 19th century.

In establishing the EEZ, this country has gained access to potentially large energy and mineral resources that may lie on or below the surface of the sea floor. Accordingly, the resources of the EEZ are a potential means of ensuring national economic security by allowing the Nation to become more self-sufficient for strategic and critical minerals. However, the United States must establish a framework for the orderly exploration and development of the EEZ and provide sufficient information regarding the EEZ to allow resolution among competing alternative uses. Private ventures in the EEZ will be encouraged and enhanced both by demonstrations of substantial potential energy and mineral resources and by the provision of regulations that allow normal competitive market forces to operate. In view of the substantial resources that may exist in the EEZ, management of the EEZ will also require adequate protection of the environment during future exploration and development activities.

The EEZ, by comparison to long-studied onshore areas, clearly is a new frontier. The exploration, characterization, understanding, management, protection, and utilization of this frontier present an exciting challenge to all elements of the U.S. marine community including academia, industry, and government. In meeting this challenge, the USGS has the very important role of developing an integrated, comprehensive scientific understanding of the EEZ as a basis for formulation of Government policies. In the President's State of the Union address of January 25, 1984, he said "The Department of the Interior will encourage careful, selective exploration and production of our vital resources in an exclusive economic zone within a 200-mile limit off our coasts....". Under the direction of the Secretary of the Interior and the Assisant Secretary for Water and Science, the USGS assumed responsibility for developing and coordinating an EEZ program of national scope. As part of this effort, the USGS marine program in the EEZ provides for the orderly exploration necessary to develop a geologic understanding of these new Federal lands. The EEZ program of the USGS serves the national need by developing or extending our understanding of where mineral or petroleum resources occur, the geologic framework in which such resources may exist, the geologic environmental conditions that may be encountered during their future exploitation, and how their formation in oceanic areas can aid in the search for analogous onshore deposits of economic significance.

A logical first step in the exploration of a new frontier is to map it. In April 1984 the USGS, in cooperation with the Institute of Oceanographic Sciences (IOS) of the United Kingdom, initiated Program EEZ-SCAN as a first effort to expand our geologic understanding of the EEZ. This program, under the direction of Project Chief James V. Gardner, was created to map the EEZ at a reconnaissance scale using a unique side-scan sonar system developed by IOS. This revolutionary system, known as GLORIA (Geological Long-Range Inclined Asdic), is capable of mapping large areas of the sea floor on a single pass of the ship. In 1984, GLORIA was used to map the EEZ off California, Oregon, and Washington with spectacular and significant results that are presented in this publication. During 1985, GLORIA was used to map the EEZ of the Gulf of Mexico and Puerto Rico. The results of those surveys are now being processed and compiled. Over the next five years, EEZ-SCAN will be extended to the EEZ of Alaska and Hawaii. We believe these surveys will provide the critical "road maps" for future EEZ research.

This publication provides a graphic overview of the west-coast EEZ, but it represents only a fraction of the information that must be collected and analyzed in the exploration of the new frontiers. It serves to illustrate how cooperative efforts between governments can successfully deal with the challenges of exploration. Most importantly, perhaps, the many new discoveries illustrated in the atlas also serve to remind us that this is a beginning, not an end, to understanding our marine heritage.



PREFACE

EEZ-SCAN 1984 and the U.S. GEOLOGICAL SURVEY'S MISSION

Long before the American Revolution, explorers were venturing westward on missions of discovery, motivated by the lure of the unknown and the quest for riches. The almost continuous westward stream of adventurers ebbed and surged in response to events as varied as the discovery of luxuriant furs in the Northwest, the addition of major land areas such as the Louisiana Purchase and Alaska, and the discovery of gold in California.

The rewards of expeditions extended beyond the bounty of a particular voyage or trek. The more lasting treasures involved new information about the discovered or more fully explored territories. Private or corporate journals were the repositories of the early findings, but when President Thomas Jefferson in 1804 ordered Meriwether Lewis and Captain William Clark on an expedition to explore the unknown country lying between the Mississippi River and the Pacific Ocean, the United States Government assumed a leadership role for all future surveys. It was not until 1879, however, that the Congress formally established the U.S. Geological Survey (USGS) to examine the substance of the national domain. The USGS has remained intact for more than 100 years owing to the importance and lasting relevance of its charge: to provide geologic, topographic, and hydrologic information that contributes to the wise management of the Nation's natural resources and that promotes the health, safety, and well-being of the people.

The western limit of exploration for many years was the shoreline of the Pacific, for the ocean beyond was too hostile and the prospect of natural resources seemed minimal. It was ignorance, not information, that temporarily thwarted our manifest destiny. World War II and the development of sonar technology effected a significant advancement of our knowledge of the ocean, particularly the sea floor. Sonar hydrographic soundings during the 1940's and 1950's resulted in the charting of the oceans. By the late 1950's the scientific community had knowledge of the depths of the world's oceanic trenches, the average depth of the ocean abyss, and the existence of the oceanic ridge system and submarine mountain chains. At that time we still believed the ocean crust represented the Earth's oldest rock; old and, therefore, dense rock that would sink the deepest into the mantle. The paradigm of plate tectonics, our understanding of sea-floor spreading, and magneto-stratigraphy have drastically altered our perception of the sea floor. What was thought to be the oldest crustal rock is now known to be the youngest; in fact, the average age of the world's ocean floor is only 69 million years. The entire global expanse of sea floor could have been generated by sea-floor spreading in only 100 to 150 million years.

Armed with the new understanding of crustal dynamics and with the help of funding generated by the exigencies of rising gold prices in the late 1960's, the USGS began marine exploration in Alaskan offshore areas. Besides discovering submerged gold-placer deposits, these seismic surveys discovered sedimentary basins along the Bering Sea shelf that now are the targets for petroleum exploration and may prove to be giant oil fields. In the early 1970's, President Nixon's Project Independence, which was intended to minimize U.S. dependence on foreign oil and resources, provided justification for a major expansion in offshore surveys. The funding for marine exploration had increased along with rising prices at the gas pump, but it plummeted because of the temporary oversupply of oil in the late 1970's and early 1980's. Organizational changes and redirection of funds brought marine exploration in U.S. waters to a near standstill by 1983. Then on March 10, 1983, President Reagan unilaterally declared an expansion to 200 nautical miles beyond the shoreline of the sovereign rights to all natural resources within the zone. This newly proclaimed Exclusive Economic Zone (EEZ) again provided a mandate for further exploration. But what could the sea floor provide? We had a good idea of the general bathymetry, but the detailed physiography of the EEZ was not well known. Only with such detailed knowledge of the sea floor could we begin to appraise its resource potential and the consequences of exploitation or other activities where man might disturb physical, biological, or chemical systems of the oceanic or sea-floor environments.

In 1984 the USGS asked colleagues from the Institute of Oceanographic Sciences (IOS) in the United Kingdom to work with us using their long-range side-scan sonar system (GLORIA) to study the entire EEZ. During the summer of 1984, IOS and USGS scientists surveyed the EEZ off California, Oregon, and Washington, an area of about 850,000 km^2. The results of this survey are the thirty-six 2° sheets, at a scale of 1:500,000, contained in this atlas. At a cost of approximately one penny per acre we can, for the first time, see broad regions of the sea floor. These acoustic images are no less remarkable than the first photographs from the farside of the Moon.

A cursory glance at the 36 sheets in this atlas reveals a plethora of geologic features: volcanic edifices, fault scarps, channels, levees, slump scars, large sediment bedforms, crustal lineaments, and textural or tonal differences that reflect varying sediment types. These images provide the framework, a "road map", to direct more detailed investigations. As land surveys commonly rely on various types of remotely sensed data, so the clearer perception of submarine features provided by GLORIA will enable marine geologists to focus on specific features of interest.

David G. Howell

EXPLANATION OF THE ATLAS FORMAT

This atlas is composed of three data sections. The first section presents the sonar mosaics of the EEZ sea floor, along with preliminary geologic interpretations and bathymetry. Following the sonar mosaics is a section providing seismic-reflection data collected during the survey. The third section presents data on residual magnetic anomalies throughout the survey area.

The tracklines of the *Farnella* for the entire survey of the EEZ of the Western Conterminous United States are shown in figures 1 and 2. The Julian day (consecutive day of the year, starting with January 1 as Julian day 1) is annotated on the tracklines once each day, the time is Greenwich Mean Time and is annotated every 12 hours, and every hour is marked by an arrowhead that gives the direction of profiling. The EEZ-SCAN survey proceeded north (beginning Julian day 118) from the southeast corner of the EEZ, near San Diego, to the U.S.-Canadian border. After traversing the northern area, the *Farnella* surveyed south along the west boundary of the entire area, profiled several tracklines along the U.S.-Mexican border, and completed the cruise in San Diego on Julian day 232. The tracklines were oriented to provide long, continuous lines and overlapping sonar coverage wherever possible, maximize the geologic information (this is usually achieved by surveying obliquely to the strike of major geomorphic and structural features), and minimize damage to the GLORIA system by rough seas. During EEZ-SCAN 84 the last consideration became the major determinant, hence the predominant east-west track orientation from Mexico to southern Oregon (figs. 1 and 2).

PROJECTION AND SCALE

The side-scan sonar mosaics and their geologic interpretations are displayed in this atlas as a series of 36 adjoining sheets, starting with sheet 1 in the extreme southeastern area of the survey and ending with sheet 36 in the northwestern area (see fig. 3). Each sheet covers two degrees of latitude from top to bottom and two degrees of longitude from side to side. A Transverse Mercator projection was used for the geographic coordinates and, because in this projection lines of longitude converge at the poles, the actual distance between the lines of longitude decreases northward. As a result, the more northern sheets are narrower than the southern sheets. The mosaics are printed at a scale of 1:500,000; each centimeter on a mosaic represents an actual distance on the Earth's surface of 5 km (or 1 inch equals about 7 nautical miles).

SONAR MOSAICS

The 36 sheets that compose this atlas present a continuous sonar mosaic of the EEZ of the Western Conterminous United States (fig. 3). The sonar mosaics are presented in the atlas as unobscured images and, on the facing page, as a screened image with a preliminary geologic interpretation. Each sheet itself is a mosaic, or collage, of photographs made from processed computer images. Each sonar image was carefully placed using both navigation tracks and alignment with features on adjacent images. Because major spatial corrections are necessary to the area directly beneath the ship, individual pixels (digital picture elements) from this zone are enlarged and create a subtle pattern that shows the path of the ship. The trackline patterns can be compared to the actual tracklines in figures 1 and 2 to obtain precise locations or to integrate seismic and magnetic data.

Land areas shown on the mosaics are from satellite photographs (band 5 of Landsat 2 MSS imagery). Resolution of the images used in this atlas is about 80 m per pixel, nearly the same as that of the sonographs (50 m per pixel).

Each mosaic sheet is a half-tone black and white print of the acoustic reflectivity of the sea floor. White represents the greatest acoustic reflectivity and black represents the lowest acoustic return. The darkness or lightness of a feature or an area on the mosaics, therefore, is a function of how much sound is reflected from the sea floor. Reflectivity, in turn, is controlled by the relief of the sea floor (height, abruptness), microtopography and roughness of the sea floor (sediment waves, bedrock irregularities), and physical properties of the sea floor (lithified rock and medium-size sand and clay deposits all have different reflectivities, for example). When viewed from the trackline, a positive-relief feature, such as a volcano, usually appears as a bright zone (the facing slope) with a dark zone (the shadow) behind it. Conversely, a negative-relief feature, such as a canyon, usually appears as a dark zone (the near wall is shadowed) followed by a bright zone (the far wall is facing the sonar beam).

In general, exposures of sea-floor crust such as seamounts, volcanoes, and oceanic ridges tend to be bright, or at least brighter than the surrounding sea floor, on most images. However, not all bright targets are indicative of sea-floor basalt. Bright patterns are also caused by certain sedimentation patterns and by steep sediment-covered slopes facing the sonar beam. Dark patterns also have a variety of causes, of which shadows and certain sediment facies are the most common.

GEOLOGIC INTERPRETATIONS

The interpretations presented here are preliminary and are not intended to be definitive or all-inclusive. They are provided to guide the reader in analyses of the sonar mosaic and to point out some of the salient and significant features, patterns, and processes that have been recognized with this data set. More detailed interpretations of the sonar data are currently in progress. The ultimate objective of this program is to verify the actual composition and origin of the features seen on the mosaics by sampling the sea floor. This will allow us to convert this sonar-image map of the EEZ into a geologic map, but this phase will require several years to complete.

Our interpretations are based largely on the processed sonar data, supplemented by information obtained from available bathymetric and seismic-reflection data. The symbols used throughout are explained in figure 4. Interpretations that are based solely on ancillary data sets and that cannot be observed on the sonar mosaic are shown as dashed lines. All other lines are solid, or if contacts or trends are uncertain, then the lines are dashed and queried. An effort has been made to identify features and zones that have significance to the tectonic and sedimentologic processes that have shaped the sea floor of the EEZ. In some cases an interpretative line is meant to be representative or symbolic; thus in a complex area of numerous oceanic ridges, the axes of most, but not all, of the ridges are shown, leaving the reader to extrapolate the interpretations to other similar features. Not all interpretations have been confirmed by other types of information, and additional study may be required to verify or refine some of the interpretations. For example, those features identified as faults on the sea floor are based only on surface lineations and offsets, and such trends can be caused in some situations by controls other than faults.

BATHYMETRY

Bathymetric contours are printed directly on each sonar mosaic along with the geologic interpretation; contours are in meters. Geographic names correspond to features identified on the airgun records in the seismic section of the atlas. The quality and accuracy of the bathymetric data vary from sheet to sheet and under no circumstances should the bathymetric maps be used for navigation. We sought to use the best data available for each sheet, and doing so required using data from several different sources. On some sheets more than one source was used; if so, a narrow zone with no bathymetry is shown between the two sets of contours. On every sheet the source of the bathymetric data is given; the full citation for each data source is provided in the reference section. Refer to figure 5 for an overview of the data sources for bathymetry used for each sheet.

On some sheets there may not be exact agreement between the location of a feature (for example, a seamount) on the bathymetric map and the same feature on the sonar mosaic. This occurs because either the feature is poorly located (and in some cases not even identified) on the bathymetric map (this is more prevalent in the outer EEZ) or because physical construction of the sonar mosaic resulted in displacement of an individual feature so as to produce the best over-all alignment of the majority of feaures.

SEISMIC AND MAGNETIC DATA

Reproductions of the seismic-reflection (airgun) records and magnetic data collected during EEZ-SCAN 84 are the second and third sections of the atlas. The bathymetric data (10 kHz) and high-resolution seismic-reflection data (3.5 kHz) are not presented in this atlas because of space limitations. Both the airgun records and the magnetic profiles are keyed to the ship's location using hour marks and Julian days.

The seismic-reflection data are presented in the seismic section in a continual sequence. Each record is annotated with the Julian day and hour, the vessel's speed in nautical miles per hour (knots), and the vessel's course in degrees. Breaks between records mark major course changes; minor course changes are identified within each record. Where appropriate, names of geographic features are annotated on the records. The vertical scale is annotated in the two-way traveltime of sound in seconds. As an approximation, each second of two-way travel equals about 750 m in the water column (based on an assumed sonic velocity in seawater of 1,500 m/s). Beneath the sea floor the speed of sound increases, and each second of two-way traveltime will equal more than 750 m (from as low as 800 m to possibly more than 1,500 m, depending on rock type and depth of burial). Occasional gaps in time occur in the records as a result of repairs being made to the airguns; such time gaps are identified with the words "No data" (other notations on the profiles are ship records). In some cases there is an actual gap in the data coverage; in other cases the vessel turned off the track course for repairs but returned to allow complete coverage. By checking the times on records against the times on the ship's tracks (figs. 1 and 2), the reader can determine whether or not an actual gap exists in the data coverage.

Total-field magnetic profiles of the sea floor obtained during the EEZ-SCAN 84 cruises are presented in a time-continuous sequence in the section entitled "Magnetic Profiles". Magnetic data were not collected during the first 11 days because the ship was operating in shallow-water areas of the southern California Continental Borderland. Starting with Julian day 128, however, the total-field magnetic data are nearly continuous; gaps exist only for periods when the *Farnella* was stopped or in port. The magnetic data are presented as the residual magnetic anomaly that was calculated by subtracting the International Geomagnetic Reference Field updated to 1979 (see IAGA Division 1 Study Group, 1976) from the measured total-field value. The residual magnetic anomaly is plotted at a scale of 500 gammas per inch, for each 24-h period. An x is placed at every 30th value along the profile. Course changes and speed changes are not shown, but that information can be easily obtained by comparing the date and time with the trackline charts (figs. 1 and 2).

THE GLORIA II SYSTEM

The GLORIA system is a long-range side-scan sonar developed at the Institute of Oceanographic Sciences, U.K. The system was specifically designed to map the morphology and texture of sea-floor features in the deep ocean. Acoustic images of the sea floor are formed by transmitting sound pulses at the sea floor to either side of the towed vehicle and recording the reflected sound waves. Two arrays of transducers mounted back to back are inside the towed vehicle. The arrays can emit pulses of energy at 20-, 30-, or 40-s intervals and, between transmissions, record the echoes from as far away as 30 km. The acoustic data are sequentially obtained from narrow strips of sea floor, and thus successive transmissions over adjacent strips of sea floor are used to construct an image line-by-line.

The maximum swath width largely depends on the prevailing acoustic propagation conditions. For GLORIA the swath width can be as great as 30 km on each side of the track. Under normal conditions, however, it is usually somewhat less. If acoustic conditions are unfavorable and the water depth is less than about 1,500 m, then the range may be less than 10 km. The maximum range for the surveys reported in this atlas is 22.5 km to either side of the ship's track. In the shallow waters of the upper continental slope and the California Continental Borderland, the maximum range obtained was considerably less.

Several factors influenced the acoustic frequency that was selected for the GLORIA system. A low frequency is desirable because sound-wave energy is absorbed in seawater, and the rate of absorption rapidly increases with the frequency of the sound wave. However, low-frequency acoustic arrays have to be large and heavy to achieve the prescribed beam shape. The GLORIA array was designed as a compromise between these factors so as to achieve both low noise levels and great stability. The operating frequency of the GLORIA system is about 6.5 kHz with the port array at 6.8 kHz and the starboard array at 6.2 kHz. Each array is 5.3 m long by 40 cm high, a configuration that gives a horizontal acoustic beam 2.7° wide and a vertical beam of 35°. The beam width is specified between half-power points, and considerable energy actually radiates outside these limits. The array is designed to confine the energy as nearly as possible to the plane perpendicular to the track and to fill the quadrant from the nadir (the point on the sea floor directly beneath the towed vehicle) up to near horizontal.

The acoustic energy reflected from the sea floor is recorded in digital format. Each pixel of the image has a size, measured along the track, that is proportional to the range and extends to hundreds of meters at extreme range because the sound beam diverges at 2.7°. The recording system was designed so that one complete scan is subdivided into 1,000 pixels. The cross-range pixel size represents about 50 m, which is smaller than the along-track pixel size, and thus features in the raw data are elongated parallel to the track, particularly at extreme range.

A few of the important technical features of the GLORIA system are provided here. For more detailed information and specifications, see Somers and others (1978). Each array consists of a total of 120 transducers, 30 to a row, 60 to each side. The vehicle is 8 m long, weighs 2.25 tons in air, and is neutrally buoyant. The array is towed by 400 m of heavy double-armoured cable with 36 electrical cores for the signals and services. There is no active depth control and, at the normal survey speed of 8 kts, the vehicle depth is about 50 m. The arrays are electrically split into six sections each, and each section has its own circuit to the ship. The arrays can handle 10 kW of power at about 90 percent efficiency. The vehicle has a compass that allows the acoustic beam to be stabilized against yaw by introducing compensating delays to the section signals. The signals are detected, amplified, filtered, and smoothed before being digitized and recorded on magnetic tape.

DIGITAL PROCESSING TECHNIQUES

INTRODUCTION

This atlas presents mosaics made from computer-processed digital side-scan sonar images collected by the GLORIA system. In order to process the digital sonar data, computer software had to be designed that would correct for both geometric and radiometric distortions that exist in the original "raw" data. This chapter describes the techniques developed by the USGS to correct and enhance GLORIA digital sonar images. A more detailed explanation of the digital processing is given by Chavez (in press).

Sonographs are a record of the acoustic backscattering properties of the sea floor; those from GLORIA represent the backscatter of the sea floor produced by a 6.5-kHz frequency. The strength of the acoustic backscatter is a convolution of several functions, the four major ones being: (1) the slope angle of a feature relative to the incident sonar signal (topographic characteristics); (2) sea-floor roughness factor, the minimum being 4 cm for the GLORIA

system (determined by the wavelength of the sonar and the grazing angle of the sonar ray to the sea floor; Sabins, 1978); (3) the variation in physical properties of the upper few tens of centimeters of the sea floor; and (4) the water "atmosphere", which attenuates the strength of the sonar signal as well as produces background noise. The backscatter was recorded as a digital number (DN) with a range of 0 to 255 discrete values (8-bit data generated from a compression of the original 12-bit data). The GLORIA system was configured during these cruises to transmit a 2-s pulse of sound every 30 s to give a maximum range of 22.5 km on each side of the ship's track. The reflected sound waves were recorded on a time basis so that the data are in a slant-range rather than a ground-range (true geographic) geometry. Also, the variations in the ship's speed with time generated variations in the size of the footprint (the area on the sea floor) of each pixel in the along-track direction. These distortions, as well as others discussed below, were corrected so that the sonograph images represent orthorectified and true plan views (assuming a flat sea floor) of acoustic backscatter patterns on the sea floor.

GEOMETRIC CORRECTIONS

The major sources of geometric distortions in data of this type are: (1) water-column offset; (2) slant-range geometry; (3) aspect or anamorphic ratio distortion; and (4) changes in the ship's speed. Each of these major distortions has been eliminated from the data presented in this atlas. Below is a brief explanation of the procedures used to correct for these geometric distortions.

The GLORIA system starts recording data as soon as the transmitted acoustical wave is terminated, and therefore the original images include pixels to both sides of the nadir (the projection directly beneath the ship) that contain non-image data. The number of non-image pixels varies along the trackline as a function of the water depth directly beneath the ship. The processing software merges the navigational and bathymetric data, recorded every four sonar scan lines, with the image data. Included as part of the header information for each image line of sonar data are the date, time, latitude, longitude, and water depth. Knowing the size of each pixel in the across-track direction and the water depth directly beneath the ship, the water-depth offset can be calculated in pixels to predict the location on each side to which the nadir pixel was mapped.

The GLORIA system is a time-based imaging device that collects image data using a near-range depression angle of approximately 90° and a far-range depression angle of 5 to 10° and generates images in slant-range geometry (Somers and others, 1978). The extreme differences in depression angles cause the original image to have major distortions. The program that corrects for water-depth offset also simultaneously corrects for slant-range geometry. Slant-range to ground-range corrections, based on depression angles at both the near-range, or nadir and far-range locations, are applied to the image to properly map each pixel to a ground-range geometry. In this particular correction, the ray path of a sound wave in water is assumed to be a straight line.

Another major geometric distortion present in GLORIA images is the aspect or anamorphic ratio that exists between the along- and across-track directions. The sampling interval in the across-track direction for the 30-s pulse-repetition rate generated pixels with an approximate resolution of 45 m. The program that corrects for the water depth and the slant-range distortions generates 50-m-resolution pixels in the across-track direction. However, the resolution in the along-track direction is dependent not only on the 30-s pulse-repetition rate but also on the ship's speed. The average resolution in the along-track direction is approximately 125 m, which produces images with an aspect-ratio distortion of about 2.5. This generates a raw image that is distorted or stretched in the along-track direction. Another related source of geometric distortion is introduced by any change that occurs in the ship's speed while it is collecting the image data. The ship's speed is mainly influenced by the direction and strength of current and wind speeds relative to the ship's course, and whether the ship is heading in a straight line or is in a turn. During EEZ-SCAN 84 the speeds varied from about 7 to 10 kts, which caused the pixel resolution in the along-track direction to vary from approximately 110 to 140 m. This introduced an "accordion" effect into the geometry of the image in the along-track direction (Chavez, in press).

The aspect-ratio distortions discussed above were removed by using the latitude and longitude values extracted from the header of each record to compute the distance travelled by the ship every 30 min (unless a turn is detected, in which case the program uses a 10-min interval). Given the distance travelled and the desired pixel size, the number of pixels required for the particular 30-min segment was calculated. To simultaneously correct for the aspect-ratio distortion, a 50-m-resolution pixel size was generated on the output image in the along-track direction. This pixel size was selected so that information in the across-track direction would not have to be omitted. This procedure corrects the image data for aspect-ratio distortions and any distortion introduced by changes in the ship's speed.

RADIOMETRIC CORRECTIONS

The second major category of processing steps deals with radiometric corrections. These steps change the DN (digital number) value of a pixel rather than its spatial location, as is the case with geometric corrections. The DN value of a pixel can be changed as a function of its current DN value, as a function of its position, or both. The radiometric corrections used for the GLORIA data in this atlas include four different corrections: (1) a shading correction to correct for the attenuation of the sonar energy in water as a function of range; (2) a power correction for very near nadir because of slow buildup; (3) speckle-noise correction; and (4) removal of striping noise.

The power drop-off problem is relatively severe in sonar images because the acoustic wave is attenuated in water as a function of approximately $1/\text{range}^3$. The method employed to correct this radiometric problem uses a two-pass algorithm. During the first pass through the data, the average DN value is computed for each column of pixels of the digital image in the along-track direction. These values are then normalized by the average of all the column averages (the overall average of the image) to generate correction coefficients for each column. The correction coefficients are then applied to each pixel during the second pass through the data. The coefficients are nonlinear and a function of range; they effectively remove attenuation in the across-track direction. This technique has the characteristics of a spatial filter that removes large horizontal low-frequency patterns that are present because of the radiometric problems introduced by the imaging system (Chavez, in press). By normalizing to the average of the image rather than to a set DN value, backscatter comparisons can be made between different areas or different images. The correction also allows areas within the image with lower or higher backscatter characteristics to be properly identified and mapped. This was not possible before the correction because the DN values were strongly modified as a function of their range position. Profiles of different areas in the across-track direction can now be used for backscatter comparisons.

The method used to remove speckle noise was to apply a small (2 samples by 2 lines) smoothing filter to the entire image. This is the best approach with GLORIA data because, besides removal of speckle noise, it helps smooth the blocky appearance that the image would have because of the 2.5X digital enlargment, by pixel duplication, that is introduced when correcting for the aspect-ratio distortion.

Another radiometric or noise problem often present in data collected by scanning devices is striping in the scan direction. A combination of high- and low-pass spatial filtering was used to remove the striping. Two separated images were generated from the input data; one composed of the high-frequency components minus the noise frequency, and the other composed of the low-frequency components minus the noise. The two resultant images were then digitally added to produce an image similar to the original but without the noise (Chavez and Soderblom, 1974). The filter shapes used to remove the striping noise from the GLORIA data were a 1-line by 71-sample high-pass filter plus a 21-line by 71-sample low-pass filter.

GEOPHYSICAL SYSTEMS

Seismic-reflection, bathymetric, and magnetic data were collected simultaneously with the side-scan sonar data along the survey trackline throughout the entire EEZ-SCAN survey. The seismic-reflection systems included a 160-in^3 airgun and a high-resolution 3.5-kHz profiler. The seismic-reflection records and the magnetic data are displayed in separate sections that follow the sonar mosaics. Below is a brief description of the geophysical systems and data format.

The IOS proton-precession magnetometer was employed only in deep-water areas (>1,000 m) of the EEZ. During the survey, the magnetic data were recorded on an analog strip recorder and also in a digital format that was merged with the navigation and bathymetry.

Bathymetric data were collected with an IOS-built transducer that operates at 10 kHz with 2 kW of power. Water depths under the ship were digitized every 6 minutes, corrected for variations in sound velocity with water depth, and merged with the navigational data on digital tape. One important use of the depth information is to provide control for removing the water-column pixels from the sonographs during the processing stage.

High-resolution seismic-reflection data were obtained using a Raytheon[1] 3.5-kHz transducer with an IOS-built correlator at a power level of 8 kW. To obtain medium-resolution and medium-penetration seismic records, the airgun was fired at 2,000 psi in 12-s intervals and the return signals were displayed at 8-s intervals. Return signals were received with a Geodynamique 2-channel digital streamer that has 50 geophones in each of the two active sections. The data were displayed on two analog recorders onboard the ship, both as direct input and as a read-after-write input to ensure that the digital taping unit was functioning. The band-pass filter for the seismic data presented here was 50 to 150 Hz.

NAVIGATION

Navigation for all the EEZ-SCAN 84 cruises was with Loran C in the hyperbolic mode with independent satellite fixes. The two navigation inputs were recorded on magnetic tape and merged into a new file using only good satellite fixes and correcting the trackline positions between good satellite fixes using the Loran C data. Our experience using the west-coast Loran C net is that the expected accuracy is no worse than about ±200 m.

In addition to the at-sea navigation accuracy, the positional accuracy of features in the image mosaics was affected by the manual production of the mosaics. However, we believe that the accuracy of the technique is within the accuracy of the navigation data.

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

PARTICIPANTS IN EEZ-SCAN 84 CRUISES

SCIENTIFIC PERSONNEL	Leg 1 latitude 31° to 35°	Leg 2 latitude 35° to 38°	Leg 3 latitude 38° to 43°	Leg 4 latitude 43° to 48°
Dr. Michael E. Field, USGS, co-chief scientist	X			
Dr. Brian D. Edwards, USGS, co-chief scientist	X			
Dr. Neil Kenyon, IOS, co-chief scientist	X			X
Dr. James V. Gardner, USGS, co-chief scientist		X		
Dr. David S. McCulloch, USGS, co-chief scientist		X		
Dr. Douglas Masson, IOS, co-chief scientist		X	X	
Dr. David A. Cacchione, USGS, co-chief scientist			X	
Dr. David E. Drake, USGS, co-chief scientist			X	
Dr. Monty A. Hampton, USGS, co-chief scientist				X
Dr. Herman A. Karl, USGS, co-chief scientist				X
Dr. Michael L. Somers, IOS, GLORIA engineer	X			X
Mr. Malcolm Harris, IOS, GLORIA engineer		X	X	
Dr. Paul R. Carlson, USGS, geologist	X			
Dr. Samuel H. Clarke, USGS, geologist			X	
Mr. Henry Chezar, USGS, photographer			X	
Mr. Bruce E. Jaffee, USGS, geologist			X	
Mr. Guy Rothwell, IOS, geologist			X	X
Mr. Robin Bonner, IOS, electronics technician			X	X
Mr. Gareth Knight, IOS, navigator			X	
Dr. Richard N. Hey, SIO, geologist	X			
Mr. George B. Tate, USGS, photographer		X		
Dr. Stephen L. Eittreim, USGS, geologist		X		
Mr. Bruce M. Richmond, USGS, geologist		X		
Mr. Jon Campbell, IOS, GLORIA engineer		X	X	
Mr. Brian Barrow, IOS, GLORIA engineer	X	X		
Mr. Edward Lawson, IOS, electronics technican	X			
Mr. Timothy Probert, IOS, navigator	X	X		
Mr. Richard Phipps, IOS, airgun technician	X	X		
Mr. Chris Flewellen, IOS, geophysicist	X			X
Mr. Colin Pelton, IOS, photographer	X			
Mr. Kris H. Johnson, USGS, photographer				X
Mr. Derek Bishop, IOS, geophysicist		X	X	
Mr. Robert Kayen, USGS, geologist				X
Mr. Thomas Wiley, USGS, geologist				X

ACKNOWLEDGMENTS

EEZ-SCAN 84 happened not only because of social and political circumstances but also because of the inspiration and determination of several key people. Parke D. Snavely, Jr., was instrumental in providing a stimulus for USGS participation in investigations of the EEZ, and we wish to express our sincere appreciation for his counsel and encouragement. Without James V. Gardner's understanding of the GLORIA system and his personal and professional familiarity with colleagues at IOS, the EEZ-SCAN 84 program would never have happened. We also acknowledge David G. Howell for his support to us at all levels as we developed and executed this program. We thank Gary Hill for his enthusiastic support in all aspects and all phases of the project.

Many, many people, from the crew aboard *M.V. Farnella* to the scientific technicians who helped produce this atlas, were involved in the myriad aspects of this program. Without the efforts of those resourceful and invaluable people, this atlas could not have been produced. We are pleased to acknowledge them and their contributions.

We first express our appreciation to the Director of the Institute of Oceanographic Sciences (IOS), U.K., Dr. Anthony S. Laughton, and the superb technical staff of IOS who have made this all possible with the design, construction, and operation of the GLORIA system. Michael Somers, Malcolm Harris, and Jack Revie, all of IOS, were instrumental in the acquisition of the side-scan sonar data and in maintaining its high quality. Capt. Roy Hadgraft and the crew of the *Farnella* cheerfully endured days on end of Force 8 conditions. Their seamanship and good humor endeared them to us all.

The mosaics of computer-processed sonar images in this atlas are the first such presentation in print. Such a presentation is possible largely owing to the monumental efforts of Pat Chavez and his group at the USGS in Flagstaff, Ariz., in the design and development of the processing software and of Joseph Coddington, at the USGS in Menlo Park, who kept the hardware up and running.

The processing of the data required more than six months of almost around-the-clock work on two computers at Menlo Park, Calif., that were dedicated to this project. David Hooper of the USGS, Menlo Park, was in charge of one of the processing units, and we express our appreciation to him and his co-workers.

The production of the atlas involved many technical skills provided by the able staff of the USGS, Menlo Park. Stuart D. Toy, Robert Ginn, Terry L. Glass, Michael E. Sheridan, Kevin Ghequiere, Koichiro R. Tanaka, and all the others under the direction of Welby K. Barentsen are largely responsible for the high quality of the images reproduced in this atlas.

The thousands of tasks that go along with an undertaking such as this were assigned to a group of dedicated scientific technicians at the USGS under the leadership of Lynne Bisagno. She coordinated many of the details of the mosaics, interpretations, bathymetric data, and other aspects. The other scientific technicians who provided assistance include Kris Johnson, William Moore, Laura Timothy, David Myers, and Robert Hall. We appreciate their dedication to the job more than we can express in an acknowledgment. Special appreciation is given to Sue Hunt who, as the voice of KAO, not only kept the ship supplied with its needs during the 100 days at sea, but also kept us informed of the outside world.

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_____1967b, Huntington Beach to Punta Sal Si Puedes: Bathymetric Map 1206N-16, scale 1:250,000.

_____1967c, Southwest of Santa Rosa Island: Bathymetric Map 1306N-19, scale 1:250,000.

_____1967d, Cape San Martin to Point Conception: Bathymetric Map 1306N-20, scale 1:250,000.

_____1968a, Tillamook Head to Heceta Head: Bathymetric Map 1308N-22, scale 1:250,000.

_____1968b, Umpqua River to Cape Ferrelo: Bathymetric Map 1308N-17, scale 1:250,000

_____1969, Point Saint George to Point Delgada: Bathymetric Map 1308N-12, scale 1:250,000.

_____1974a, Vicinity Point Sur to Point Reyes: Bathymetric Map 1307N-11B, scale 1:250,000.

_____1974b, Point Reyes to Tolo Bank: Bathymetric Map 1307N-18B, scale 1:250,000.

_____1974c, North Pacific Ocean: Seamap Series 12042-12B, scale 1:1,000,000.

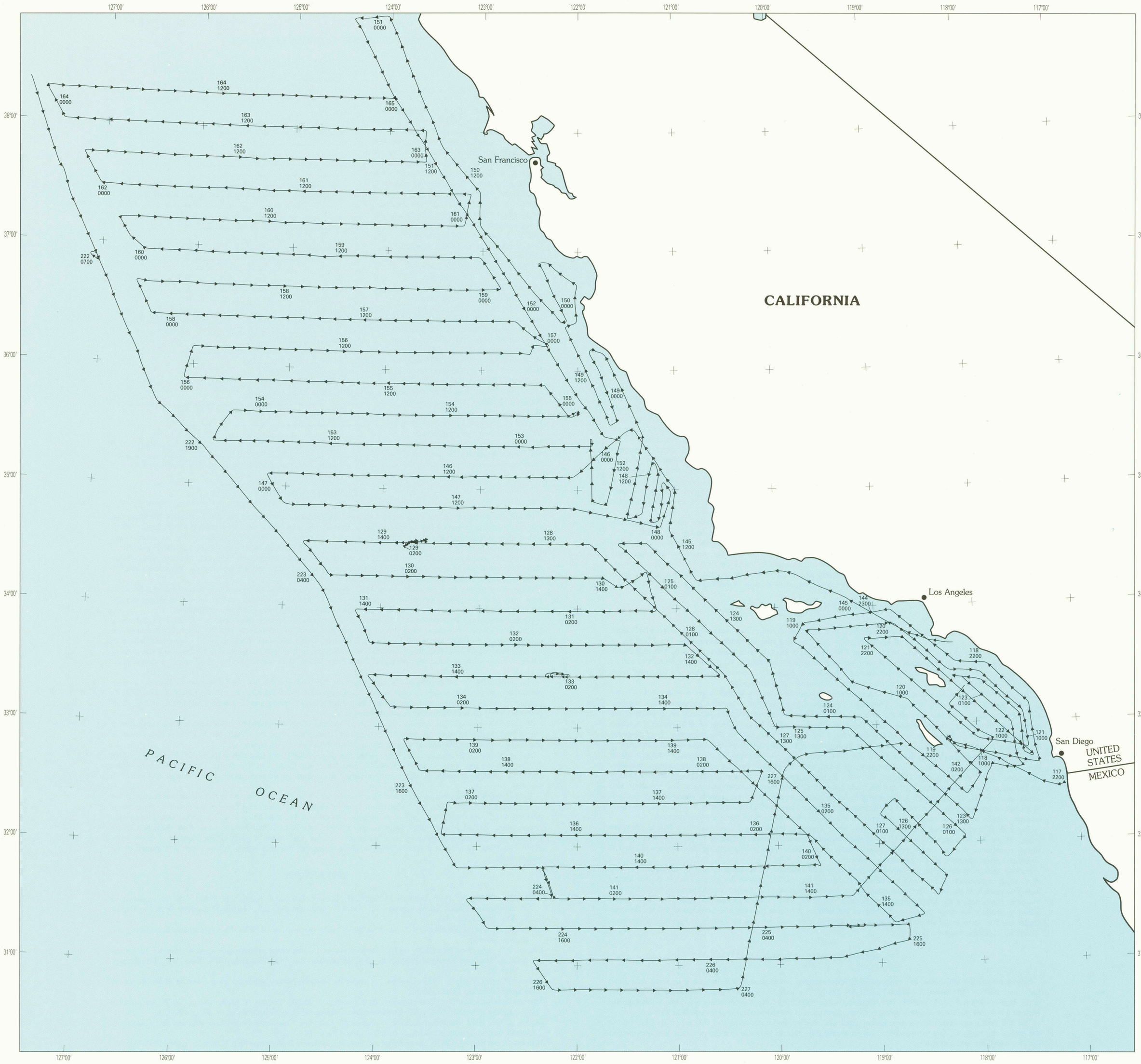
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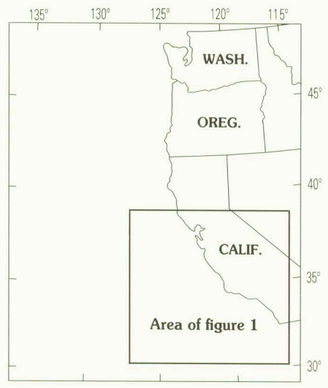
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SCALE 1:2,500,000

50 0 50 100 150 200 NAUTICAL MILES

50 0 50 100 150 200 250 300 KILOMETERS



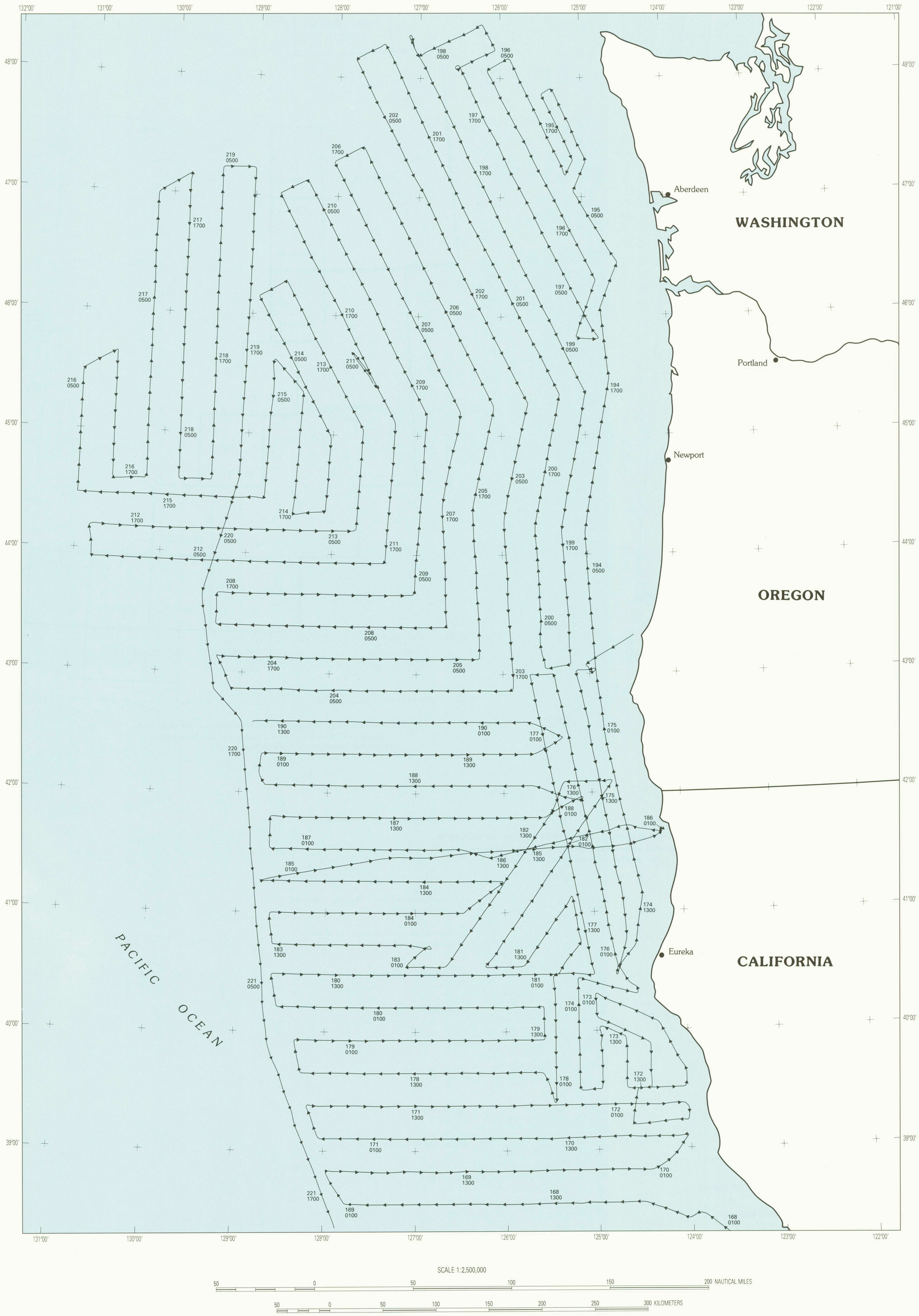
INDEX MAP

EXPLANATION

137
1400

Trackline—Arrows indicate direction ship was moving and are marked at 60-minute intervals. Numbers indicate Julian day and hour (keyed to seismic and magnetic profiles)

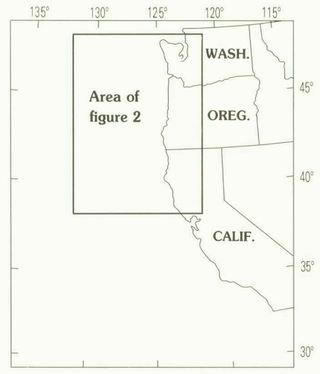
Figure 1.—Index map showing tracklines of ship for south half of Exclusive Economic Zone.



EXPLANATION

208
1700

Trackline—Arrows indicate direction ship was moving and are marked at 60-minute intervals. Numbers indicate Julian day and hour (keyed to seismic and magnetic profiles)



INDEX MAP

SCALE 1:2,500,000

50 0 50 100 150 200 NAUTICAL MILES

50 0 50 100 150 200 250 300 KILOMETERS

Figure 2.—Index map showing tracklines of ship for north half of Exclusive Economic Zone.

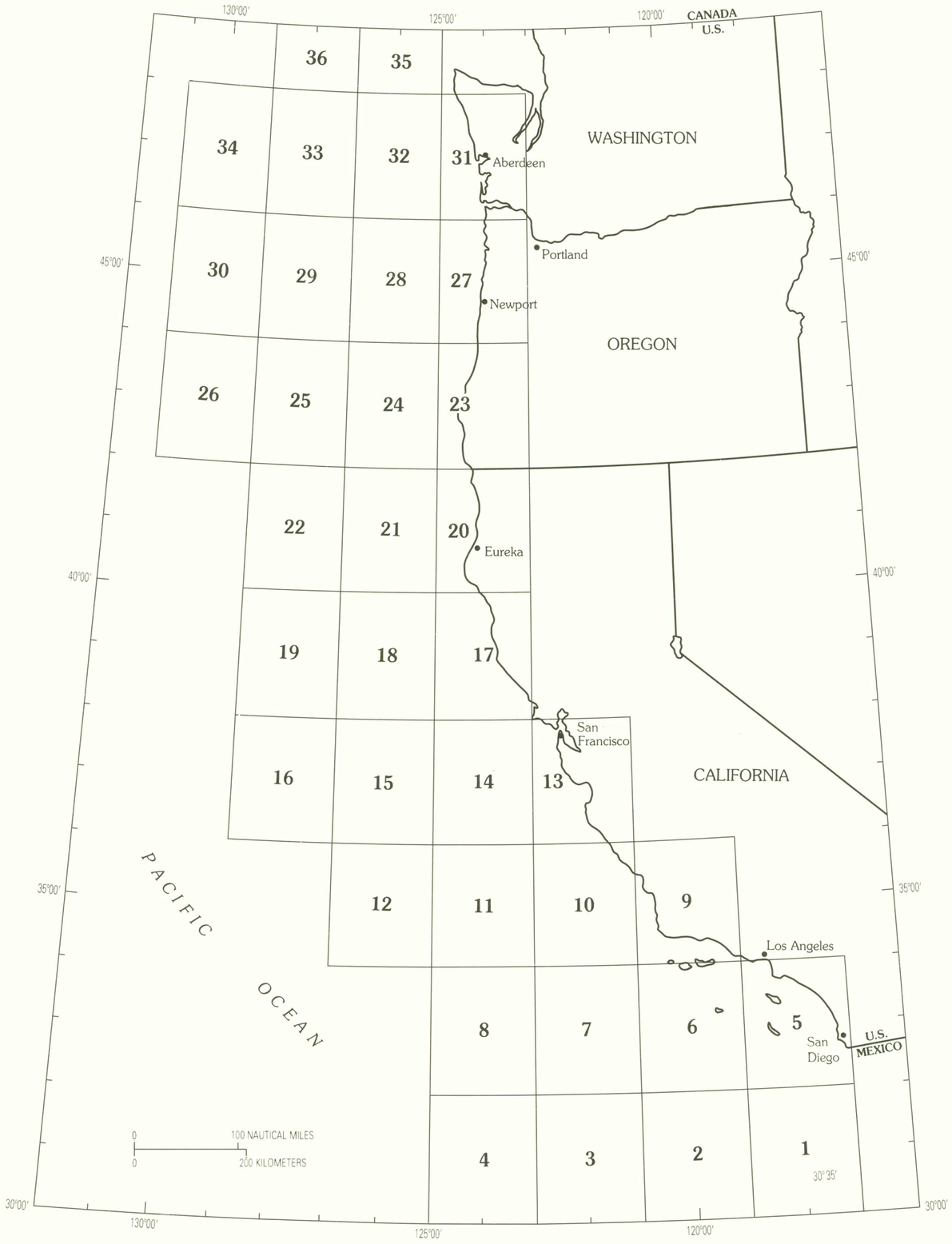


Figure 3.—Index map showing locations of the side-scan sonar mosaics (sheets 1–36 in section on sonar mosaics).

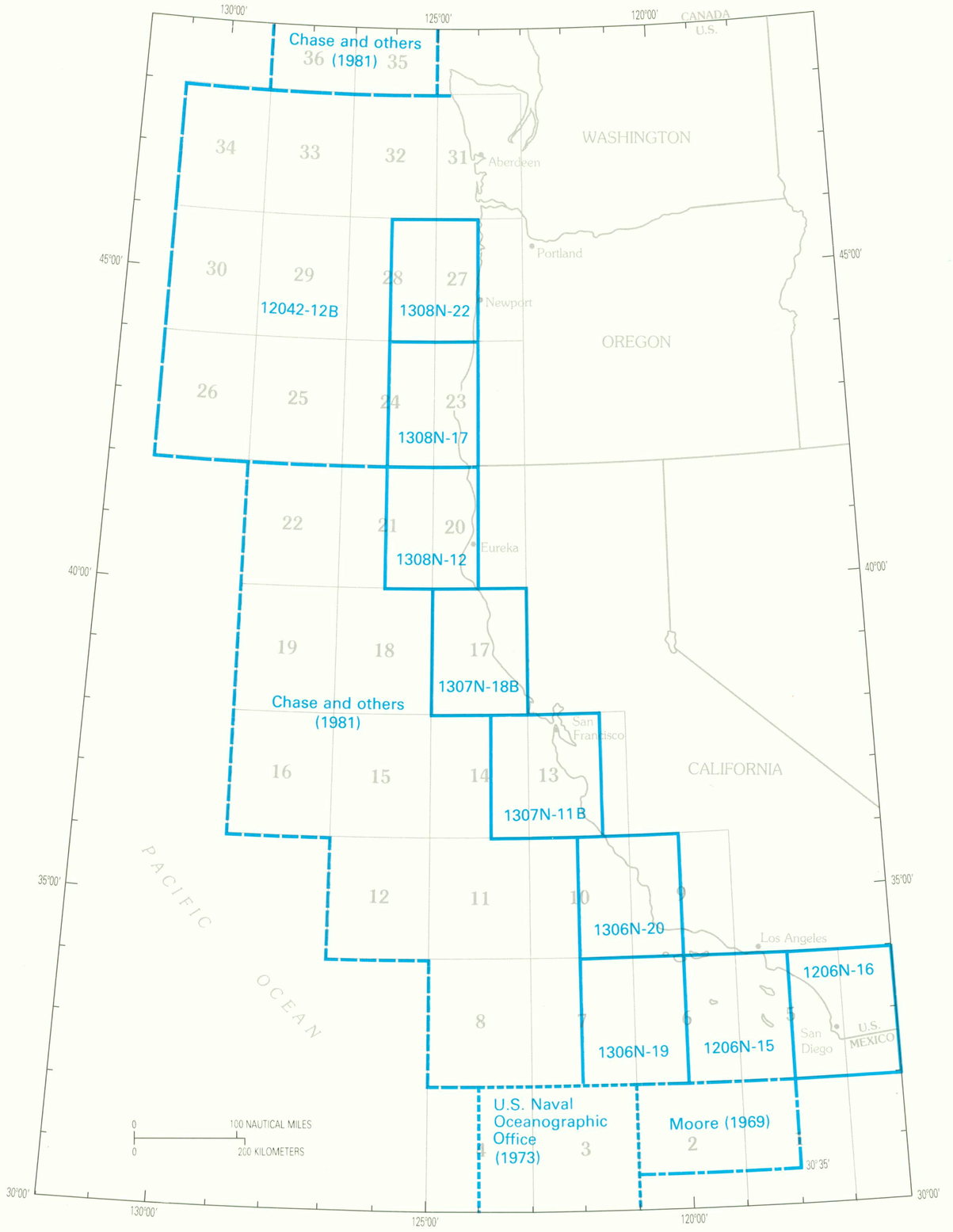


Figure 5.—Index map showing locations of bathymetric base maps used for sheets 1–36 in section on sonar mosaics. Numbers refer to maps by the National Ocean Survey (see References).

EXPLANATION FOR INTERPRETATION OF SONAR MOSAICS

[Line solid where seen on GLORIA image; dashed where seen on other data; queried where uncertain]

- BT — Basement trend or basement ridge
- F — Fault
- C — Canyon
- CH — Narrow channel
- Broad channel or canyon—Line at edge of channel floor. Hachures point to center of channel
- Flow direction of sediment
- Slump fold
- L — Levee crest
- Gully
- Broad spreading center
- Narrow spreading center
- Crest of slope ridge
- Escarpment—Line at top of escarpment. Hachures point down slope
- EB — Base of escarpment
- TF — Tectonic front
- B — Outline of basement outcrop that may or may not be of volcanic origin
- V — Outline of volcano or volcanic cluster where volcanic origin is clearly shown
- RT — Spreading-ridge topography
- DL — Depositional lobe
- S — Slump
- DF — Debris flow
- BB — Basin boundary
- CS — Area of channel scrolls
- BF — Bedform field
- D — Diapir
- CR — Canyon rim—Gullies flow down to canyon floor
- Basement-related feature
- Sediment-related feature

Figure 4.—Explanation for geologic interpretation of sonar mosaics (sheets 1–36 in section on sonar mosaics).

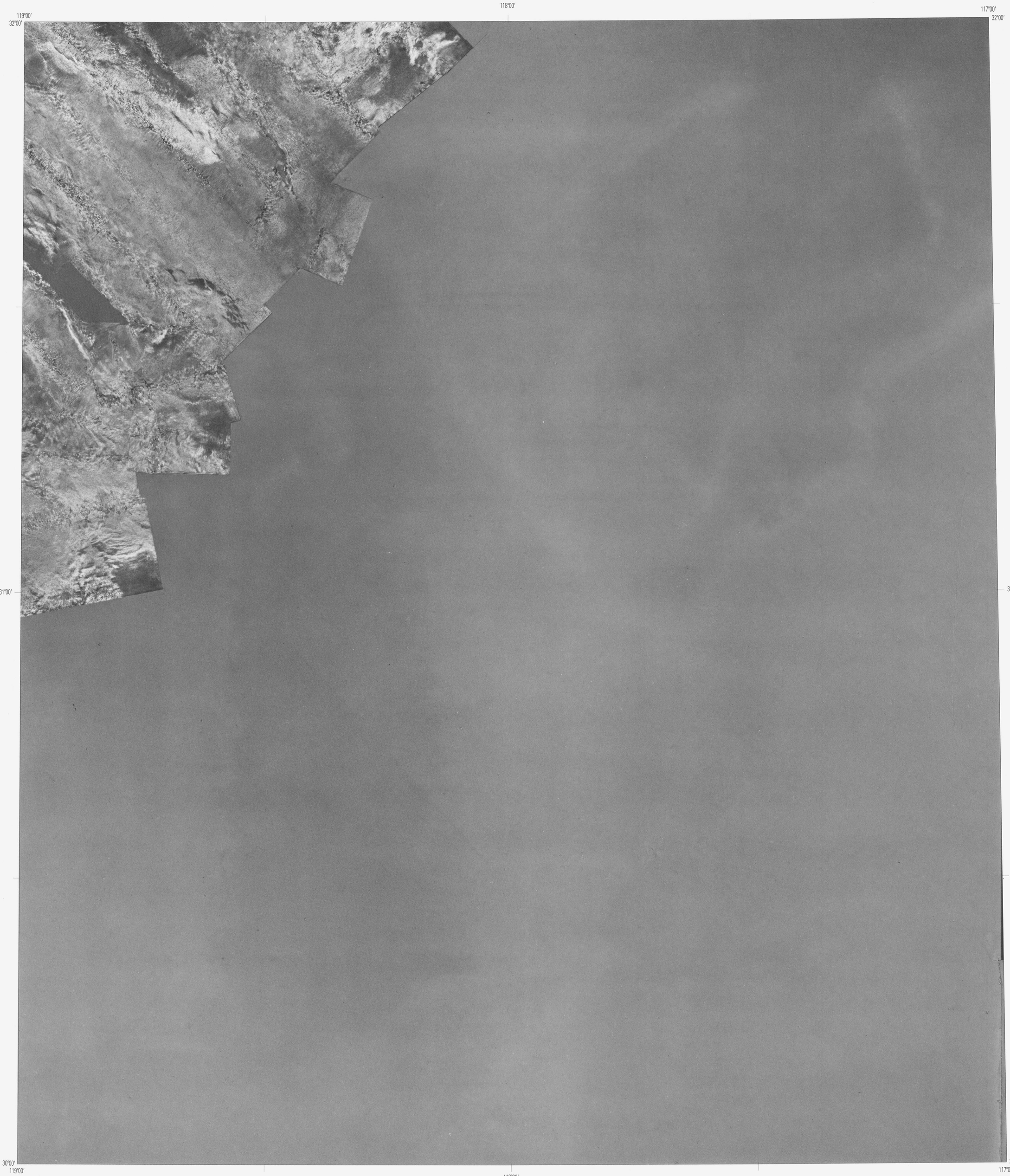
SONAR MOSAICS
AND
GEOLOGIC INTERPRETATIONS

SONAR MOSAICS WITH GEOLOGIC INTERPRETATIONS AND BATHYMETRY (SHEETS 1-36)

DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

SONAR MOSAIC
SHEET 1

ATLAS OF THE EXCLUSIVE ECONOMIC ZONE
WESTERN CONTERMINOUS UNITED STATES
I-1792



NO DATA

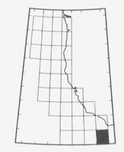
SCALE 1:500,000

10 0 10 20 30 NAUTICAL MILES

10 0 10 20 30 40 50 KILOMETERS

TRANSVERSE MERCATOR PROJECTION

1 centimeter equals 5 kilometers



SHEET LOCATION

GEOLOGIC INTERPRETATION
SHEET 1
BATHYMETRY



Base from Moore (1969)

NO DATA

SCALE 1:500,000

10 0 10 20 30 NAUTICAL MILES

10 0 10 20 30 40 50 KILOMETERS

TRANSVERSE MERCATOR PROJECTION

1 centimeter equals 5 kilometers

SHEET LOCATION

BATHYMETRIC CONTOUR INTERVAL 100 METERS

SONAR MOSAIC
SHEET 2



NO DATA

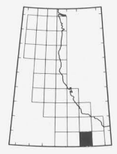
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10 0 10 20 30 40 50 KILOMETERS

TRANSVERSE MERCATOR PROJECTION

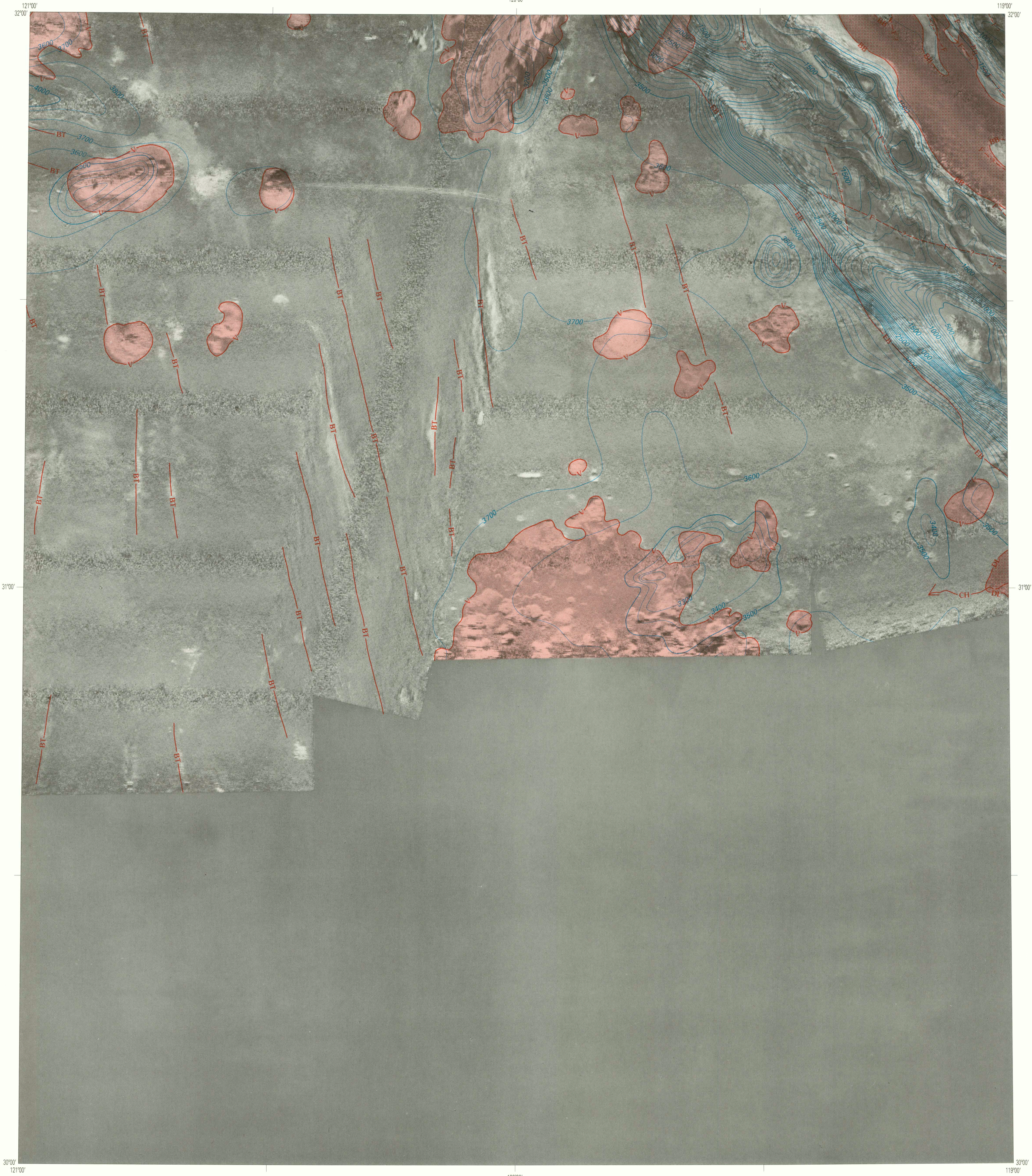
1 centimeter equals 5 kilometers



SHEET LOCATION

GEOLOGIC INTERPRETATION
SHEET 2
BATHYMETRY

121°00′ 120°00′ 119°00′
32°00′ 31°00′ 30°00′



Base from Moore (1969)

NO DATA

SCALE 1:500,000

10 0 10 20 30 NAUTICAL MILES

10 0 10 20 30 40 50 KILOMETERS

TRANSVERSE MERCATOR PROJECTION

1 centimeter equals 5 kilometers

SHEET LOCATION

BATHYMETRIC CONTOUR INTERVAL 100 METERS

**SONAR MOSAIC
SHEET 3**



NO DATA

SCALE 1:500,000

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10 0 10 20 30 40 50 KILOMETERS

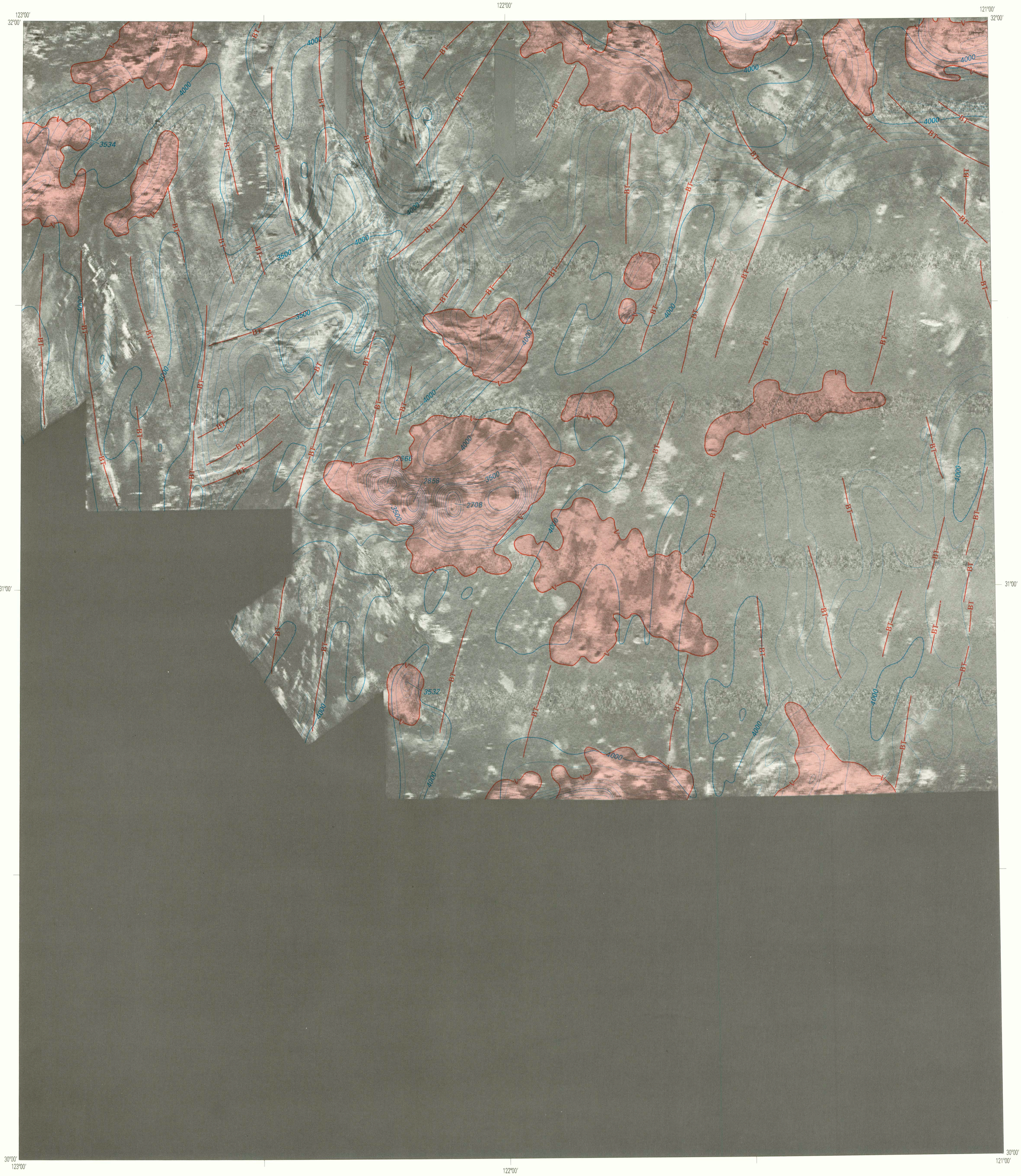
TRANSVERSE MERCATOR PROJECTION

1 centimeter equals 5 kilometers



SHEET LOCATION

GEOLOGIC INTERPRETATION
SHEET 3
BATHYMETRY



Base from U.S. Naval Oceanographic Office (1973)

NO DATA

SCALE 1:500,000

10 0 10 20 30 NAUTICAL MILES

10 0 10 20 30 40 50 KILOMETERS

TRANSVERSE MERCATOR PROJECTION

1 centimeter equals 5 kilometers

SHEET LOCATION

BATHYMETRIC CONTOUR INTERVAL 100 METERS

SONAR MOSAIC
SHEET 4



NO DATA

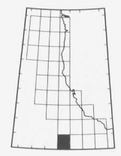
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10 0 10 20 30 40 50 KILOMETERS

TRANSVERSE MERCATOR PROJECTION

1 centimeter equals 5 kilometers



SHEET LOCATION

GEOLOGIC INTERPRETATION
SHEET 4
BATHYMETRY



Base from U.S. Naval Oceanographic Office (1973)

NO DATA

SCALE 1:500,000

10 0 10 20 30 NAUTICAL MILES

10 0 10 20 30 40 50 KILOMETERS

TRANSVERSE MERCATOR PROJECTION

1 centimeter equals 5 kilometers

SHEET LOCATION

BATHYMETRIC CONTOUR INTERVAL 100 METERS



NO DATA

SCALE 1:500,000

10 0 10 20 30 NAUTICAL MILES

10 0 10 20 30 40 50 KILOMETERS

TRANSVERSE MERCATOR PROJECTION

1 centimeter equals 5 kilometers



SHEET LOCATION

GEOLOGIC INTERPRETATION
SHEET 5
BATHYMETRY

119°00′ 118°00′ 117°00′
34°00′
33°00′
32°00′

LOS ANGELES
SAN DIEGO
UNITED STATES
MEXICO
SANTA CATALINA ISLAND
SAN CLEMENTE ISLAND
SANTA MONICA BASIN
REDONDO KNOLL
SAN PEDRO ESCARPMENT
SAN PEDRO BASIN
Lasuen Knoll
Catalina Canyon
CATALINA ESCARPMENT
CATALINA BASIN
SAN CLEMENTE ESCARPMENT
SAN NICOLAS BASIN
SANTO TOMAS KNOLL
EAST CORTES BASIN
BLAKE KNOLLS
SAN CLEMENTE BASIN
THIRTYMILE BANK
FORTYMILE BANK
SIXTYMILE BANK
GULF OF SANTA CATALINA
SAN DIEGO TROUGH
La Jolla Canyon
CORONADO BANK

DL CH B BB F?

Base from National Ocean Survey (1967a), Map 1206N–15

Base from National Ocean Survey (1967b), Map 1206N–16

NO DATA

SCALE 1:500,000

10 0 10 20 30 NAUTICAL MILES

10 0 10 20 30 40 50 KILOMETERS

TRANSVERSE MERCATOR PROJECTION

1 centimeter equals 5 kilometers

BATHYMETRIC CONTOUR INTERVAL 100 METERS

SHEET LOCATION

SONAR MOSAIC
SHEET 6

121°00′
120°00′
119°00′
34°00′
33°00′
32°00′

NO DATA

SCALE 1:500,000

10 0 10 20 30 NAUTICAL MILES

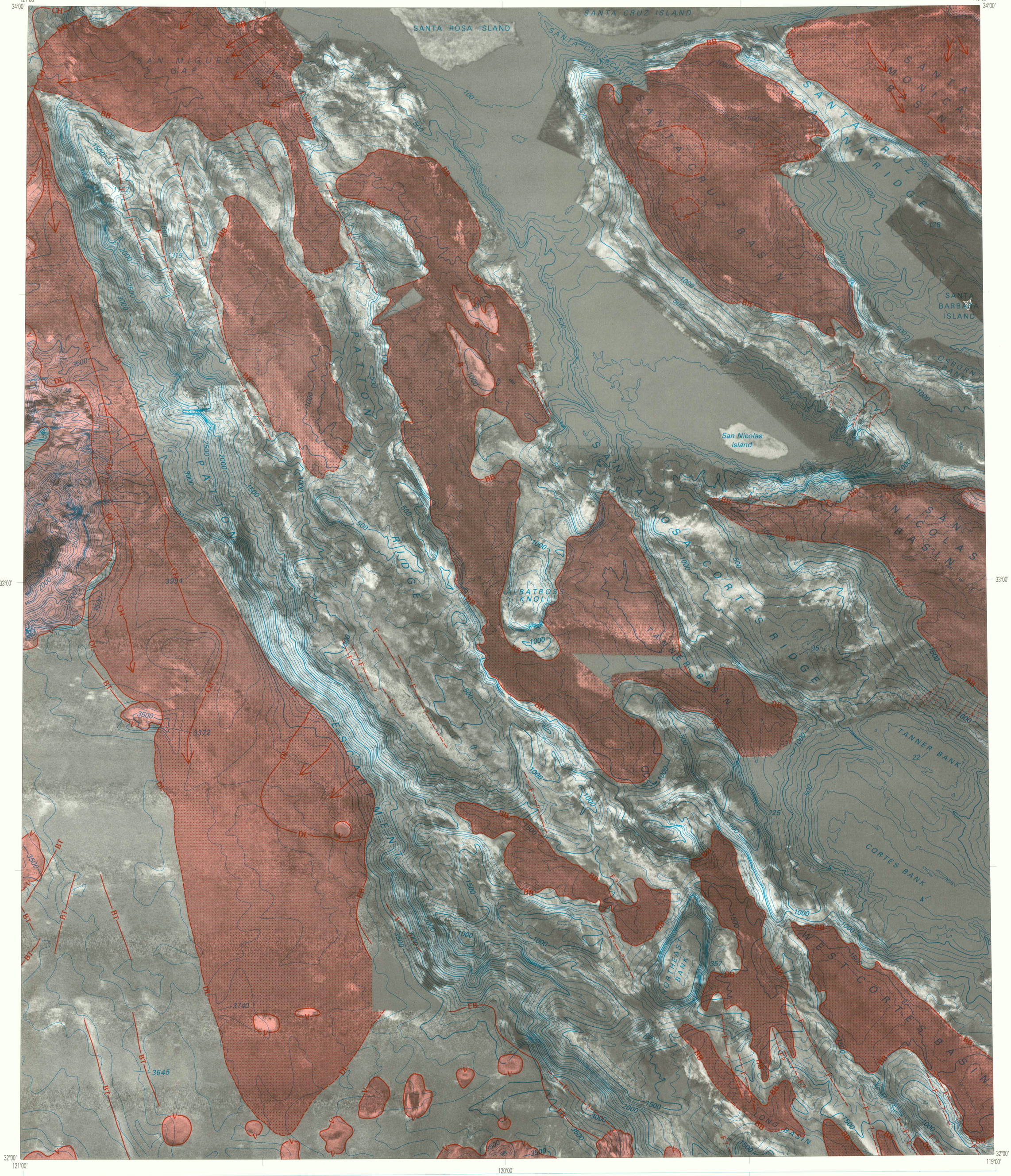
10 0 10 20 30 40 50 KILOMETERS

TRANSVERSE MERCATOR PROJECTION

1 centimeter equals 5 kilometers

SHEET LOCATION

GEOLOGIC INTERPRETATION
SHEET 6
BATHYMETRY



Base from National Ocean Survey (1967c), Map 1306N–19

Base from National Ocean Survey (1967a), Map 1206N–15

NO DATA

SCALE 1:500,000

10 0 10 20 30 NAUTICAL MILES

10 0 10 20 30 40 50 KILOMETERS

TRANSVERSE MERCATOR PROJECTION

1 centimeter equals 5 kilometers

SHEET LOCATION

BATHYMETRIC CONTOUR INTERVAL 100 METERS

SONAR MOSAIC
SHEET 7

123°00′ 122°00′ 121°00′
34°00′ 33°00′ 32°00′

NO DATA

SCALE 1:500,000

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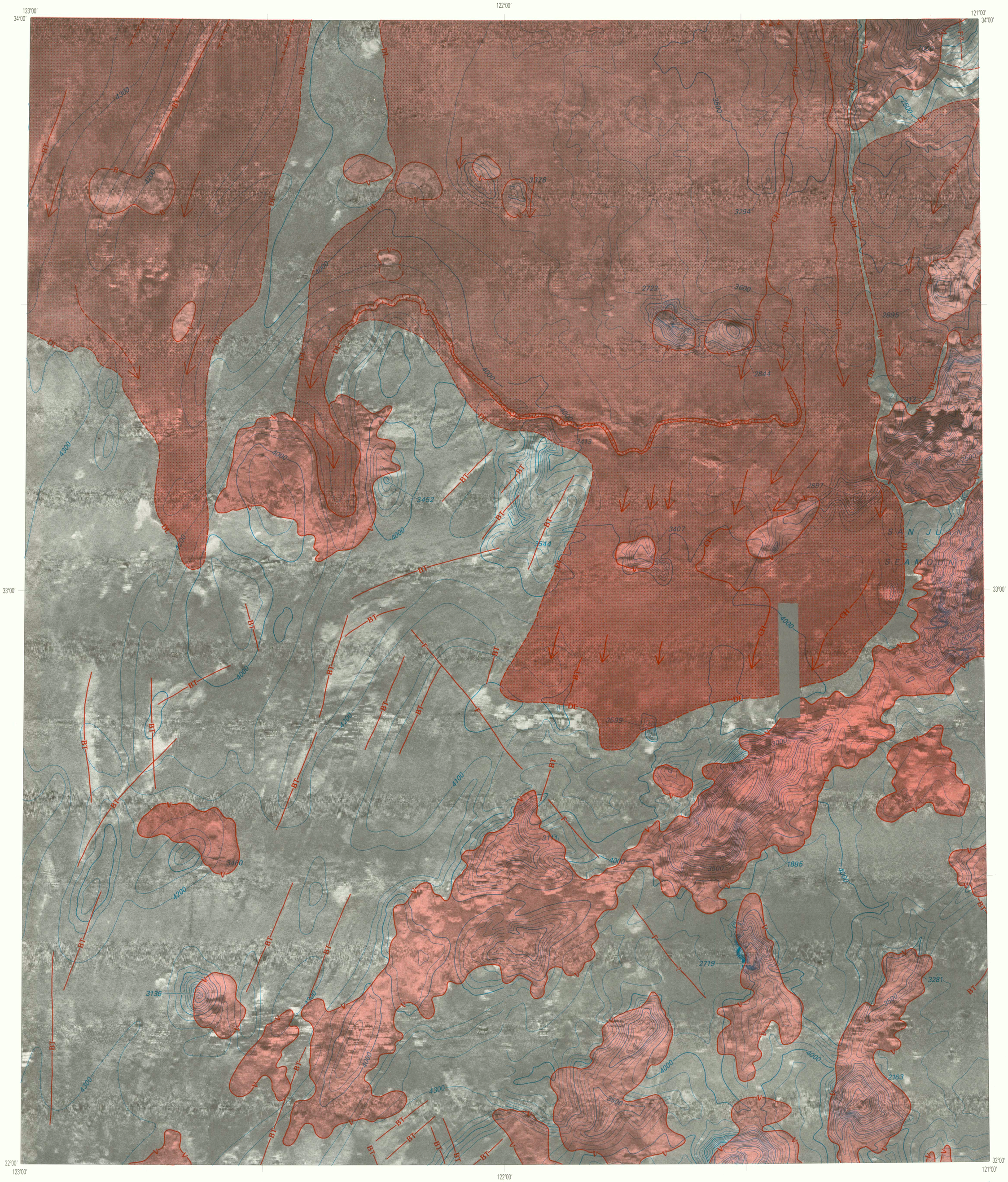
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TRANSVERSE MERCATOR PROJECTION

1 centimeter equals 5 kilometers

SHEET LOCATION

GEOLOGIC INTERPRETATION
SHEET 7
BATHYMETRY



Base from Chase and others (1981)

Base from National Ocean Survey (1967c), Map 1306N–19

NO DATA

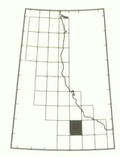
SCALE 1:500,000

10 0 10 20 30 NAUTICAL MILES

10 0 10 20 30 40 50 KILOMETERS

TRANSVERSE MERCATOR PROJECTION

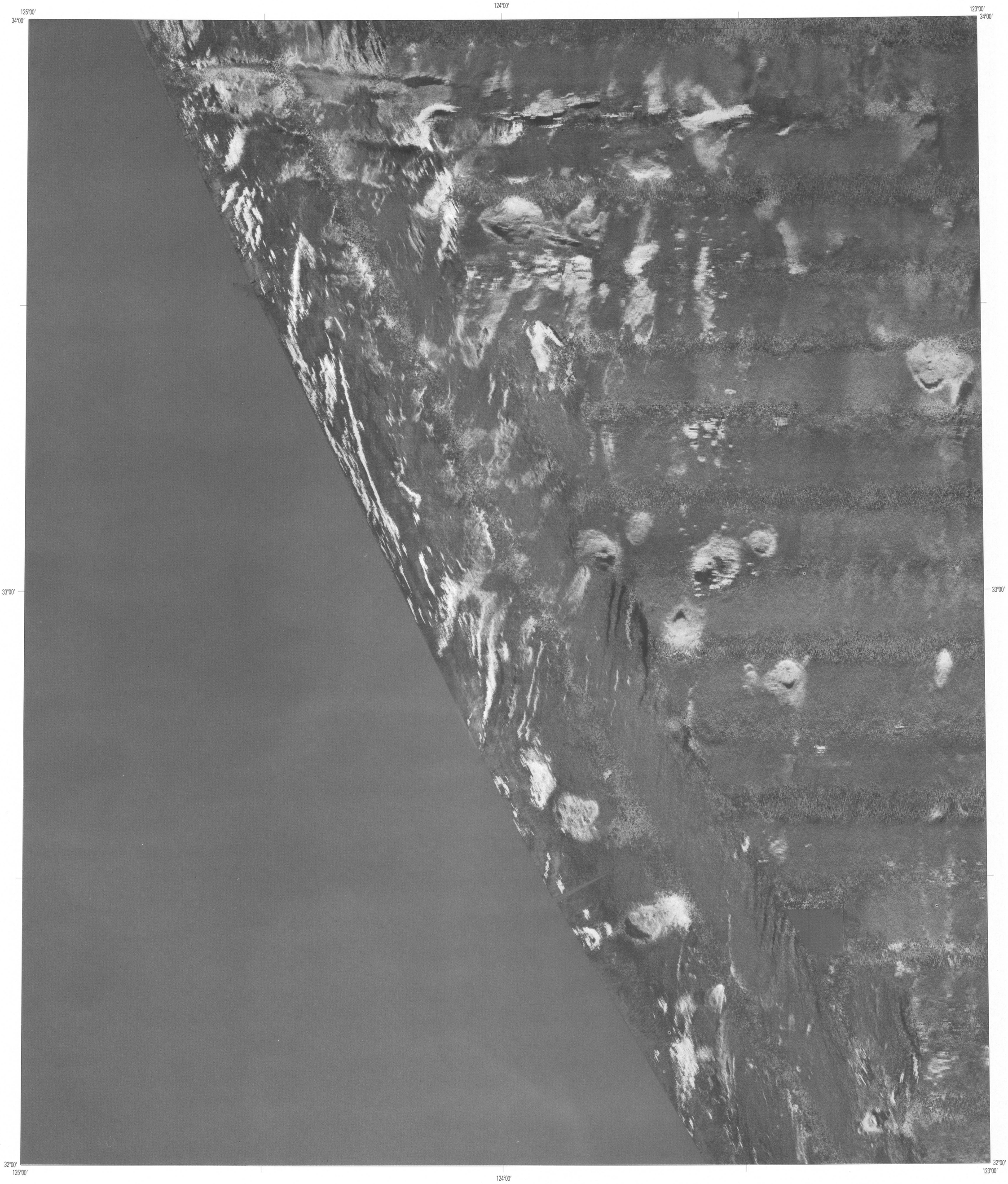
1 centimeter equals 5 kilometers



SHEET LOCATION

BATHYMETRIC CONTOUR INTERVAL 100 METERS

SONAR MOSAIC
SHEET 8



NO DATA

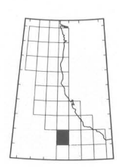
SCALE 1:500,000

10 0 10 20 30 NAUTICAL MILES

10 0 10 20 30 40 50 KILOMETERS

TRANSVERSE MERCATOR PROJECTION

1 centimeter equals 5 kilometers



SHEET LOCATION

GEOLOGIC INTERPRETATION
SHEET 8
BATHYMETRY

125°00′ 124°00′ 123°00′
34°00′ 33°00′ 32°00′



Base from Chase and others (1981)

NO DATA

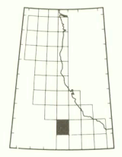
SCALE 1:500,000

10 0 10 20 30 NAUTICAL MILES

10 0 10 20 30 40 50 KILOMETERS

TRANSVERSE MERCATOR PROJECTION

1 centimeter equals 5 kilometers



SHEET LOCATION

BATHYMETRIC CONTOUR INTERVAL 100 METERS



NO DATA

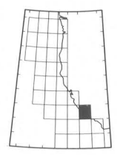
SCALE 1:500,000

10 0 10 20 30 NAUTICAL MILES

10 0 10 20 30 40 50 KILOMETERS

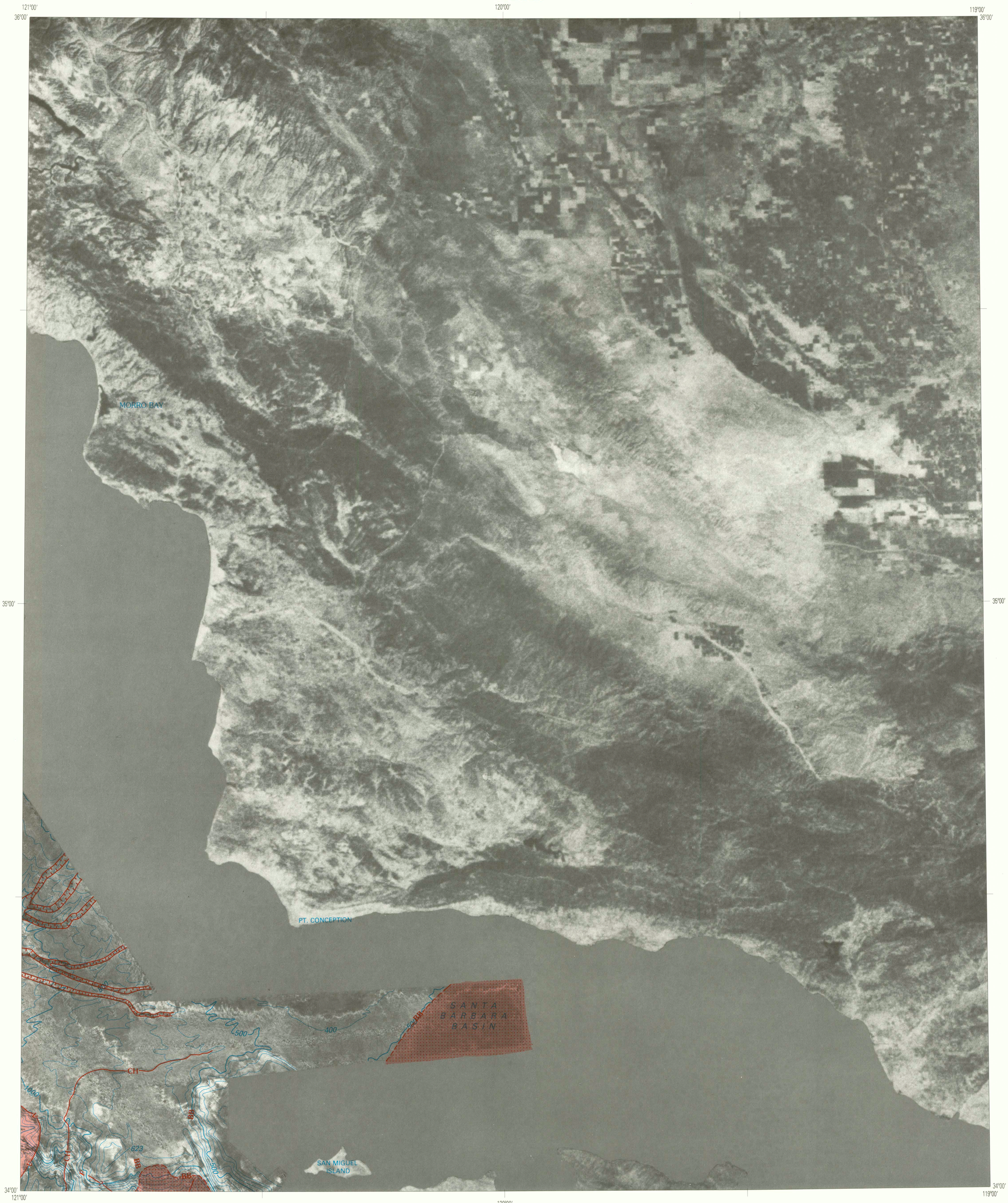
TRANSVERSE MERCATOR PROJECTION

1 centimeter equals 5 kilometers



SHEET LOCATION

GEOLOGIC INTERPRETATION
SHEET 9
BATHYMETRY



Base from National Ocean Survey (1967d), Map 1306N–20

NO DATA

SCALE 1:500,000

10 0 10 20 30 NAUTICAL MILES

10 0 10 20 30 40 50 KILOMETERS

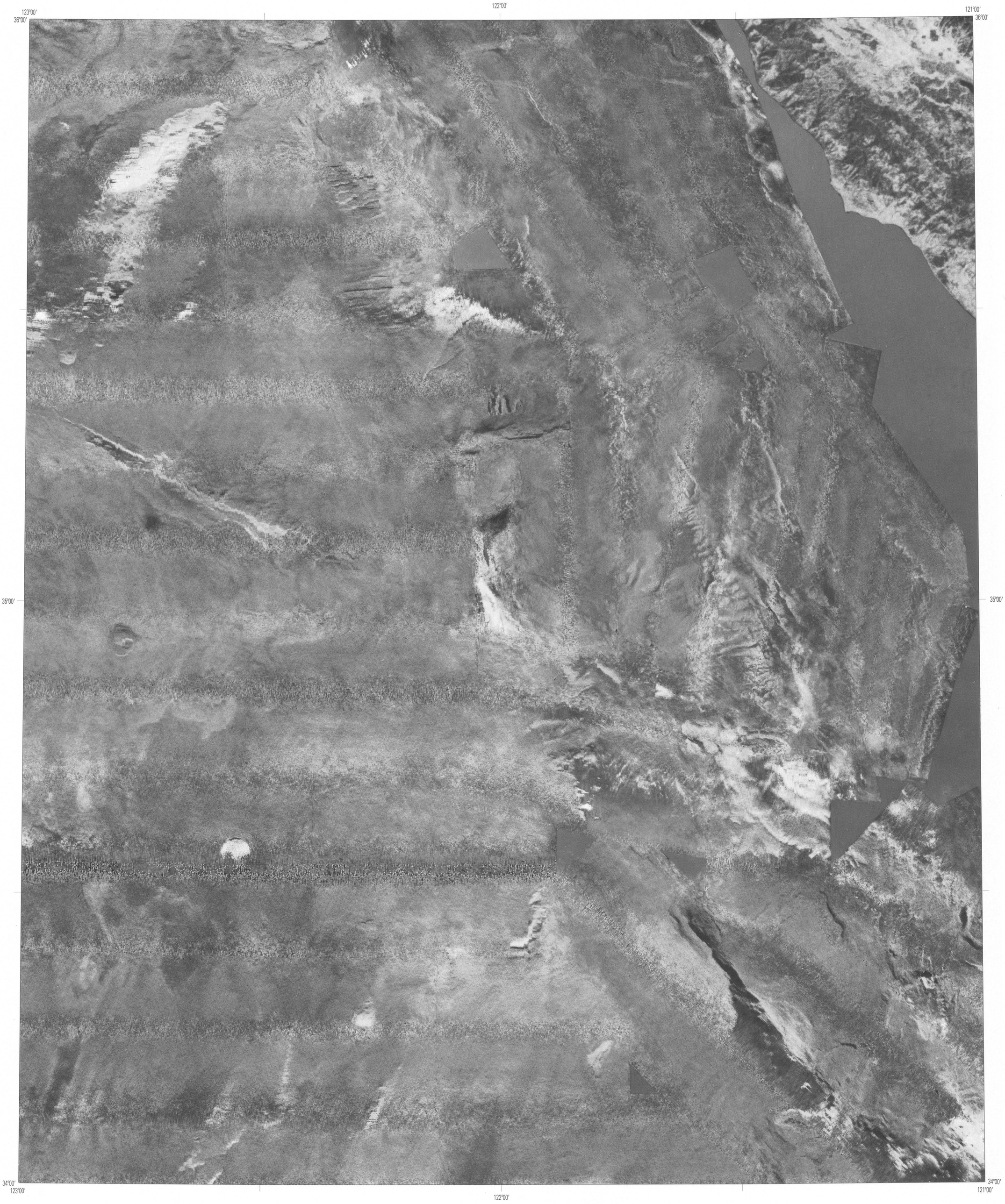
TRANSVERSE MERCATOR PROJECTION

1 centimeter equals 5 kilometers

SHEET LOCATION

BATHYMETRIC CONTOUR INTERVAL 100 METERS

SONAR MOSAIC
SHEET 10



NO DATA

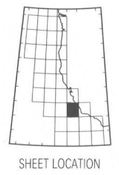
SCALE 1:500,000

10 0 10 20 30 NAUTICAL MILES

10 0 10 20 30 40 50 KILOMETERS

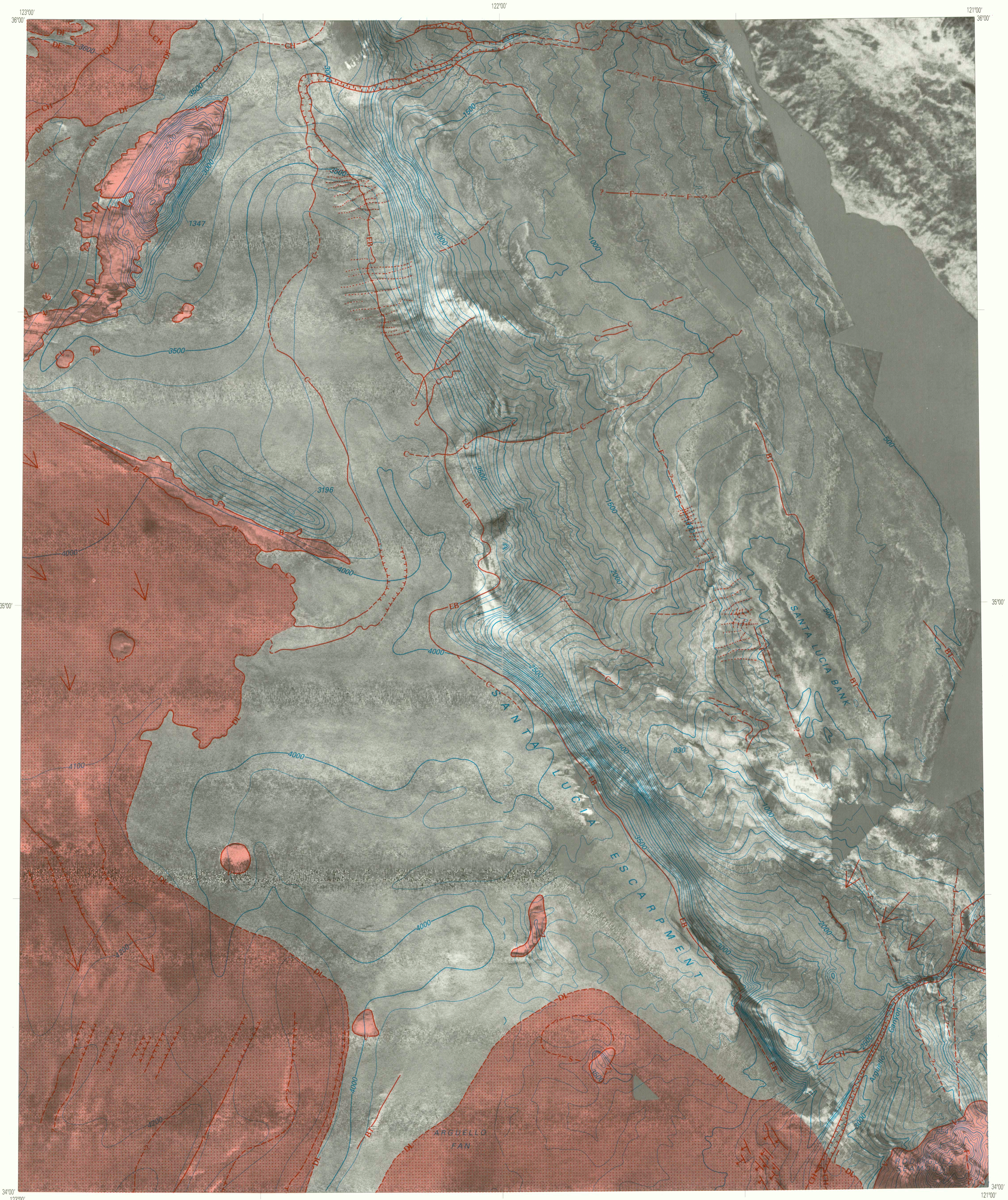
TRANSVERSE MERCATOR PROJECTION

1 centimeter equals 5 kilometers



SHEET LOCATION

GEOLOGIC INTERPRETATION
SHEET 10
BATHYMETRY



Base from Chase and others (1981)

Base from National Ocean Survey (1967d), Map 1306N-20

NO DATA

SCALE 1:500,000

10 0 10 20 30 NAUTICAL MILES

10 0 10 20 30 40 50 KILOMETERS

TRANSVERSE MERCATOR PROJECTION

1 centimeter equals 5 kilometers

BATHYMETRIC CONTOUR INTERVAL 100 METERS

SHEET LOCATION



NO DATA

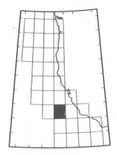
SCALE 1:500,000

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10 0 10 20 30 40 50 KILOMETERS

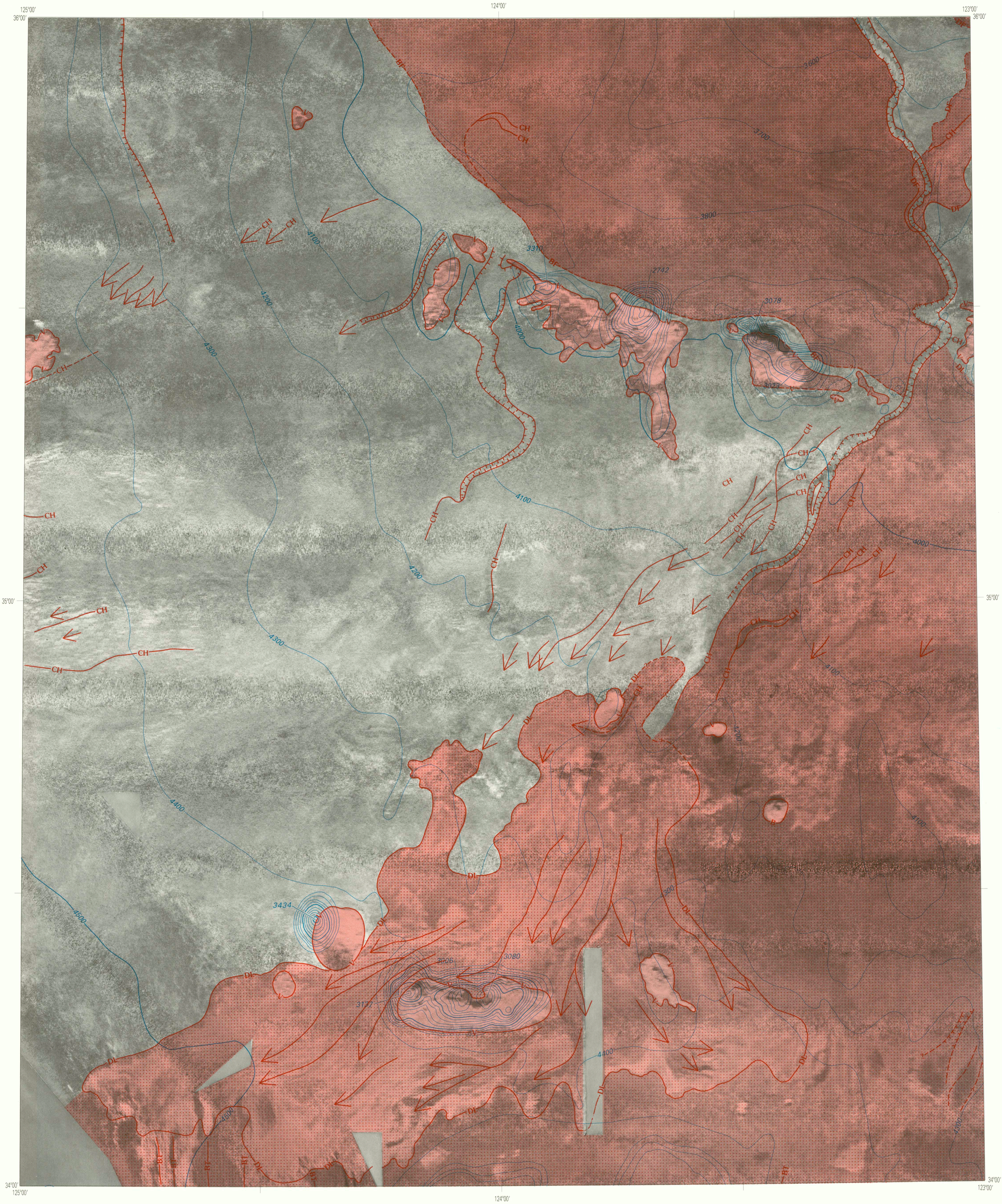
TRANSVERSE MERCATOR PROJECTION

1 centimeter equals 5 kilometers



SHEET LOCATION

GEOLOGIC INTERPRETATION
SHEET 11
BATHYMETRY



Base from Chase and others (1981)

NO DATA

SCALE 1:500,000

10 0 10 20 30 NAUTICAL MILES

10 0 10 20 30 40 50 KILOMETERS

TRANSVERSE MERCATOR PROJECTION

1 centimeter equals 5 kilometers

SHEET LOCATION

BATHYMETRIC CONTOUR INTERVAL 100 METERS



NO DATA

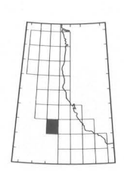
SCALE 1:500,000

10 0 10 20 30 NAUTICAL MILES

10 0 10 20 30 40 50 KILOMETERS

TRANSVERSE MERCATOR PROJECTION

1 centimeter equals 5 kilometers



SHEET LOCATION

GEOLOGIC INTERPRETATION
SHEET 12
BATHYMETRY



Base from Chase and others (1981)

NO DATA

SCALE 1:500,000

10 0 10 20 30 NAUTICAL MILES

10 0 10 20 30 40 50 KILOMETERS

TRANSVERSE MERCATOR PROJECTION

1 centimeter equals 5 kilometers

SHEET LOCATION

BATHYMETRIC CONTOUR INTERVAL 100 METERS

123°00′ 122°00′ 121°00′
38°00′ 38°00′

37°00′ 37°00′

36°00′ 36°00′
123°00′ 122°00′ 121°00′

NO DATA

SCALE 1:500,000

10 0 10 20 30 NAUTICAL MILES

10 0 10 20 30 40 50 KILOMETERS

TRANSVERSE MERCATOR PROJECTION

1 centimeter equals 5 kilometers



SHEET LOCATION

GEOLOGIC INTERPRETATION
SHEET 13
BATHYMETRY

123°00′ 122°00′ 121°00′
38°00′ 37°00′ 36°00′

SAN FRANCISCO
Menlo Park
Monterey
ASCENSION CANYON
MONTEREY
Carmel Canyon
Carmel Canyon
Arlington Canyon

BT
C
CH
DF
500
1000
1500
2000
2500
3000
3500

Base from National Ocean Survey (1974a), Map 1307N-11B

NO DATA

SCALE 1:500,000

10 0 10 20 30 NAUTICAL MILES

10 0 10 20 30 40 50 KILOMETERS

TRANSVERSE MERCATOR PROJECTION
1 centimeter equals 5 kilometers

SHEET LOCATION

BATHYMETRIC CONTOUR INTERVAL 100 METERS



NO DATA

SCALE 1:500,000

10 0 10 20 30 NAUTICAL MILES

10 0 10 20 30 40 50 KILOMETERS

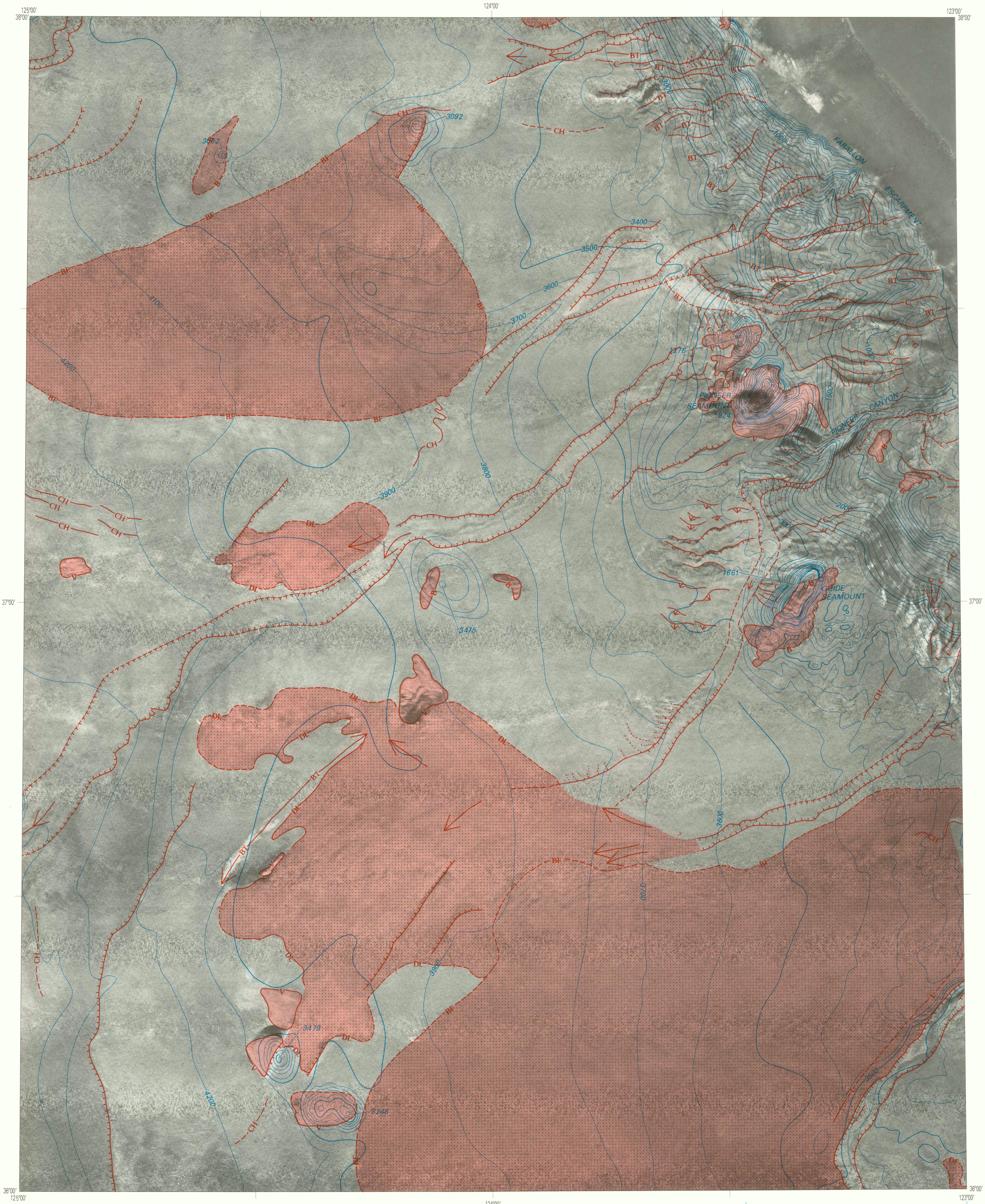
TRANSVERSE MERCATOR PROJECTION

1 centimeter equals 5 kilometers



SHEET LOCATION

GEOLOGIC INTERPRETATION
SHEET 14
BATHYMETRY



Base from Chase and others (1981)

Base from National Ocean Survey (1974a), Map 1307N–11 B

NO DATA

SCALE 1:500,000

10 0 10 20 30 NAUTICAL MILES

10 0 10 20 30 40 50 KILOMETERS

TRANSVERSE MERCATOR PROJECTION

1 centimeter equals 5 kilometers

SHEET LOCATION

BATHYMETRIC CONTOUR INTERVAL 100 METERS



NO DATA

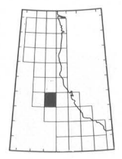
SCALE 1:500,000

10 0 10 20 30 NAUTICAL MILES

10 0 10 20 30 40 50 KILOMETERS

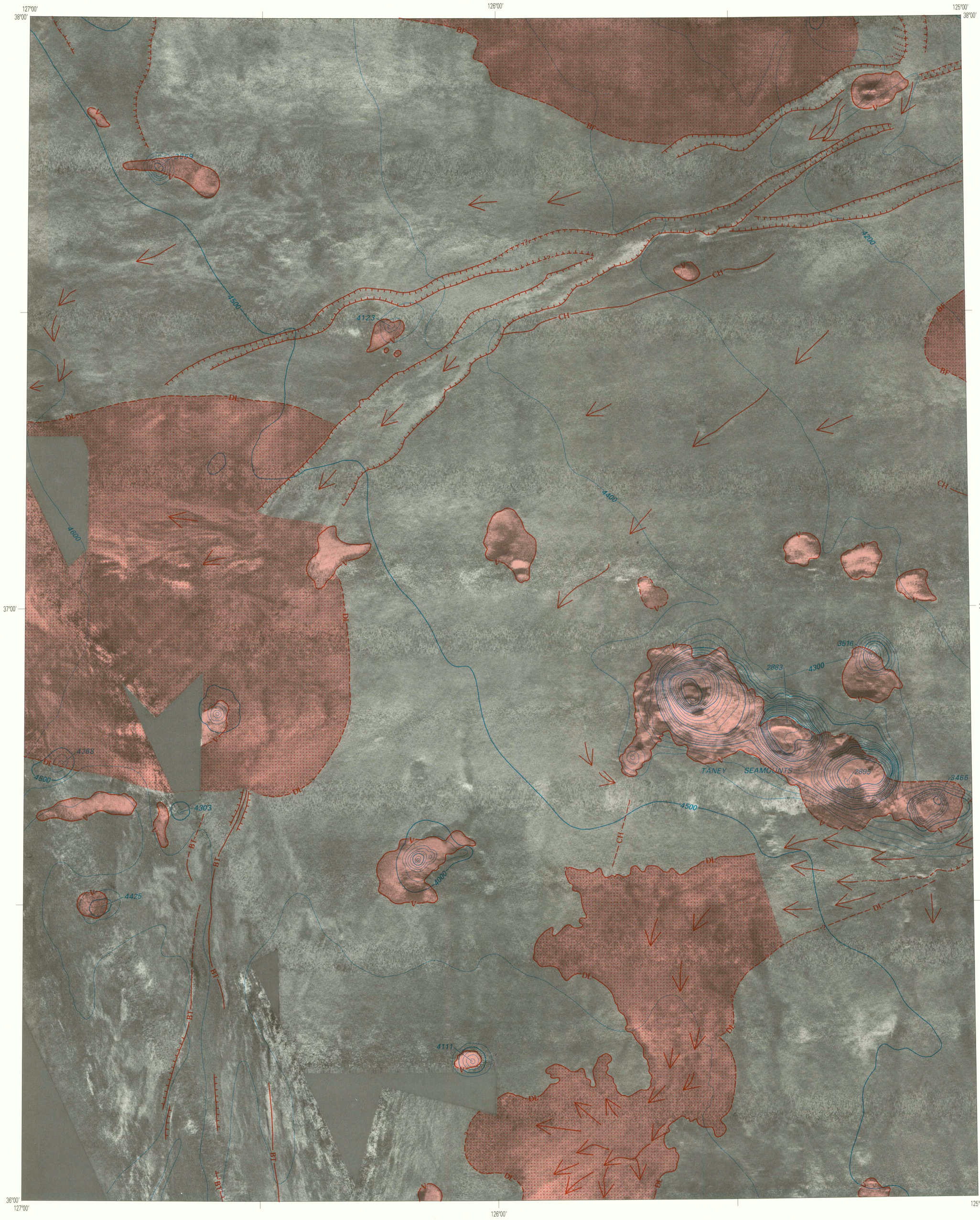
TRANSVERSE MERCATOR PROJECTION

1 centimeter equals 5 kilometers



SHEET LOCATION

GEOLOGIC INTERPRETATION
SHEET 15
BATHYMETRY



Base from Chase and others (1981)

NO DATA

SCALE 1:500,000

10 0 10 20 30 NAUTICAL MILES

10 0 10 20 30 40 50 KILOMETERS

TRANSVERSE MERCATOR PROJECTION

1 centimeter equals 5 kilometers

SHEET LOCATION

BATHYMETRIC CONTOUR INTERVAL 100 METERS



NO DATA

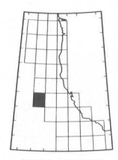
SCALE 1:500,000

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10 0 10 20 30 40 50 KILOMETERS

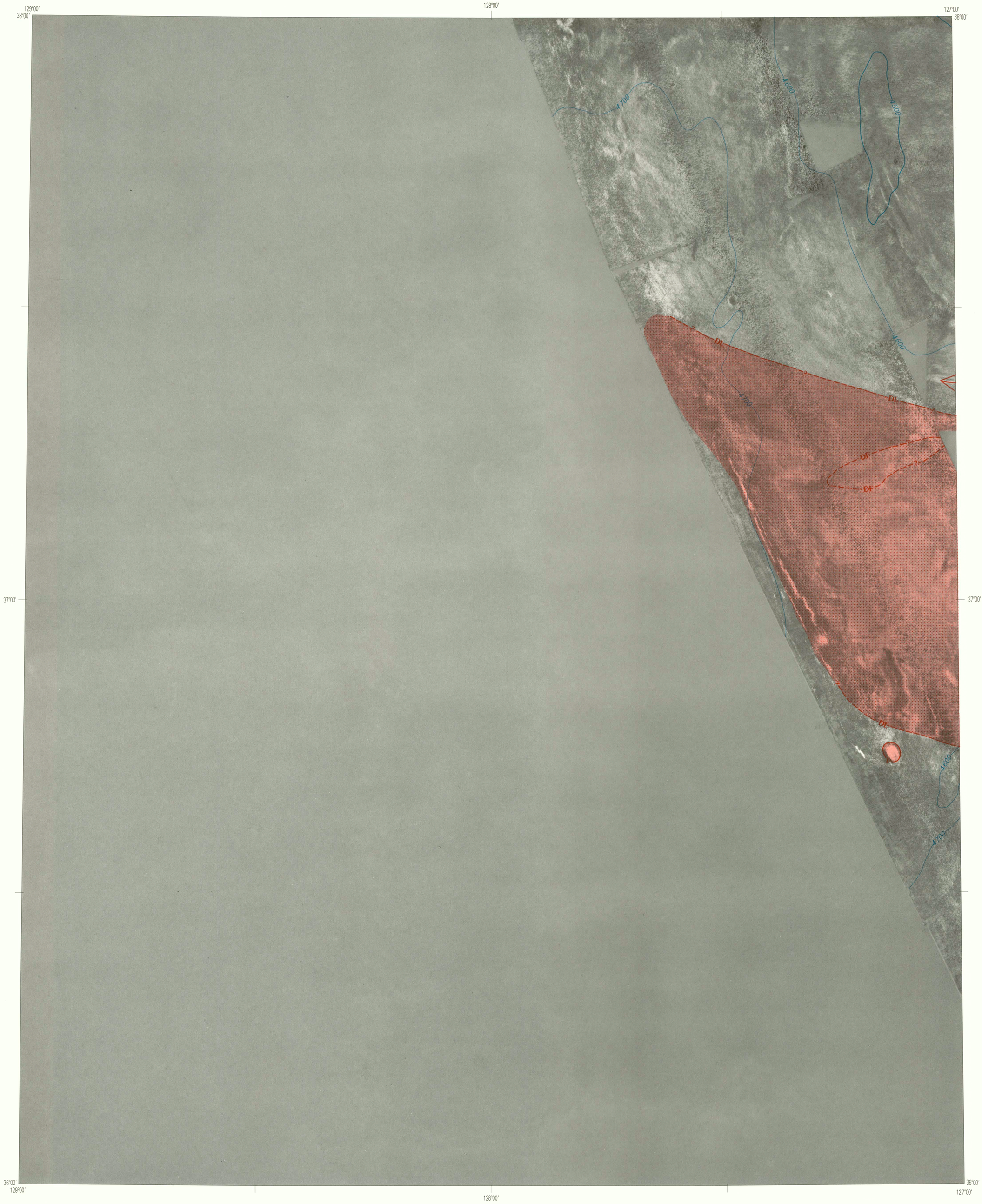
TRANSVERSE MERCATOR PROJECTION

1 centimeter equals 5 kilometers



SHEET LOCATION

GEOLOGIC INTERPRETATION
SHEET 16
BATHYMETRY



Base from Chase and others (1981)

NO DATA

SCALE 1:500,000

10 0 10 20 30 NAUTICAL MILES

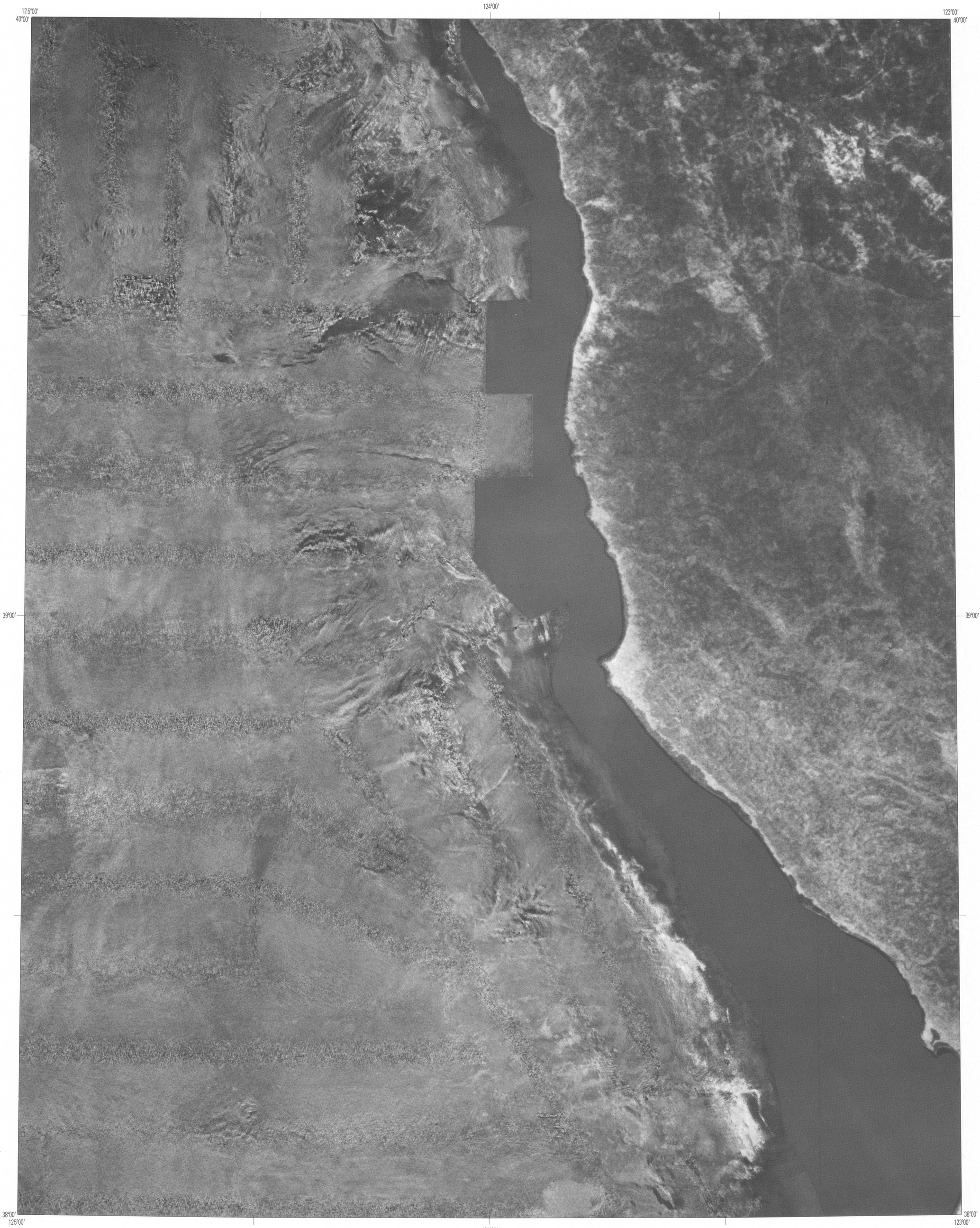
10 0 10 20 30 40 50 KILOMETERS

TRANSVERSE MERCATOR PROJECTION

1 centimeter equals 5 kilometers

SHEET LOCATION

BATHYMETRIC CONTOUR INTERVAL 100 METERS



NO DATA

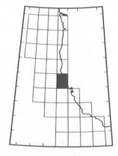
SCALE 1:500,000

10 0 10 20 30 NAUTICAL MILES

10 0 10 20 30 40 50 KILOMETERS

TRANSVERSE MERCATOR PROJECTION

1 centimeter equals 5 kilometers



SHEET LOCATION

GEOLOGIC INTERPRETATION
SHEET 17
BATHYMETRY



Base from National Ocean Survey (1974b), 1307N–18B

NO DATA

SCALE 1:500,000

10 0 10 20 30 NAUTICAL MILES

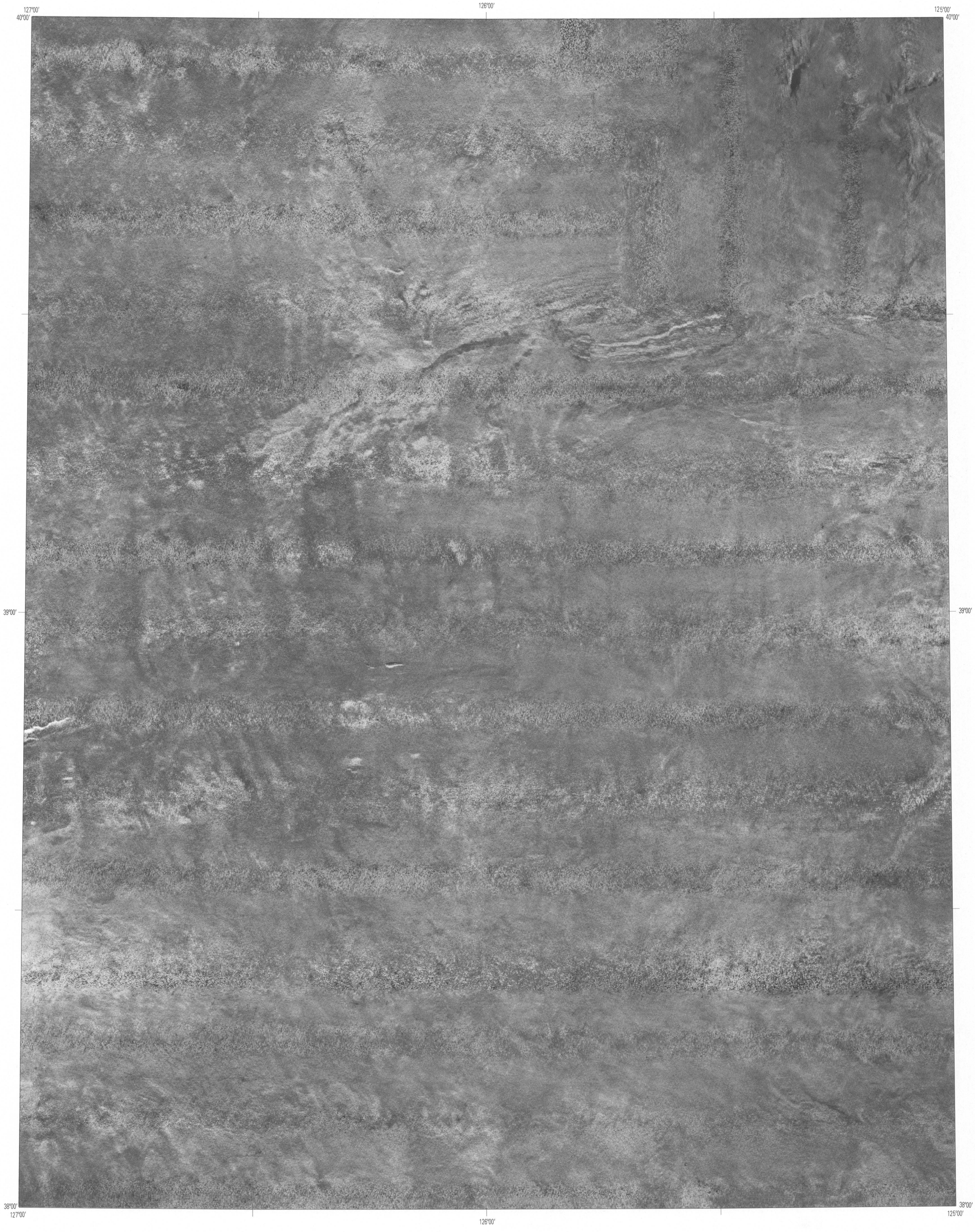
10 0 10 20 30 40 50 KILOMETERS

TRANSVERSE MERCATOR PROJECTION

1 centimeter equals 5 kilometers

SHEET LOCATION

BATHYMETRIC CONTOUR INTERVAL 100 METERS



NO DATA

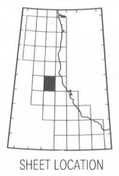
SCALE 1:500,000

10 0 10 20 30 NAUTICAL MILES

10 0 10 20 30 40 50 KILOMETERS

TRANSVERSE MERCATOR PROJECTION

1 centimeter equals 5 kilometers



SHEET LOCATION

GEOLOGIC INTERPRETATION
SHEET 18
BATHYMETRY



Base from Chase and others (1981)

NO DATA

SCALE 1:500,000

10 0 10 20 30 NAUTICAL MILES

10 0 10 20 30 40 50 KILOMETERS

TRANSVERSE MERCATOR PROJECTION

1 centimeter equals 5 kilometers

SHEET LOCATION

BATHYMETRIC CONTOUR INTERVAL 100 METERS

SONAR MOSAIC
SHEET 19



NO DATA

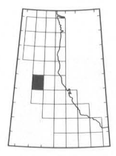
SCALE 1:500,000

10 0 10 20 30 NAUTICAL MILES

10 0 10 20 30 40 50 KILOMETERS

TRANSVERSE MERCATOR PROJECTION

1 centimeter equals 5 kilometers



SHEET LOCATION

GEOLOGIC INTERPRETATION
SHEET 19
BATHYMETRY



Base from Chase and others (1981)

NO DATA

SCALE 1:500,000

10 0 10 20 30 NAUTICAL MILES

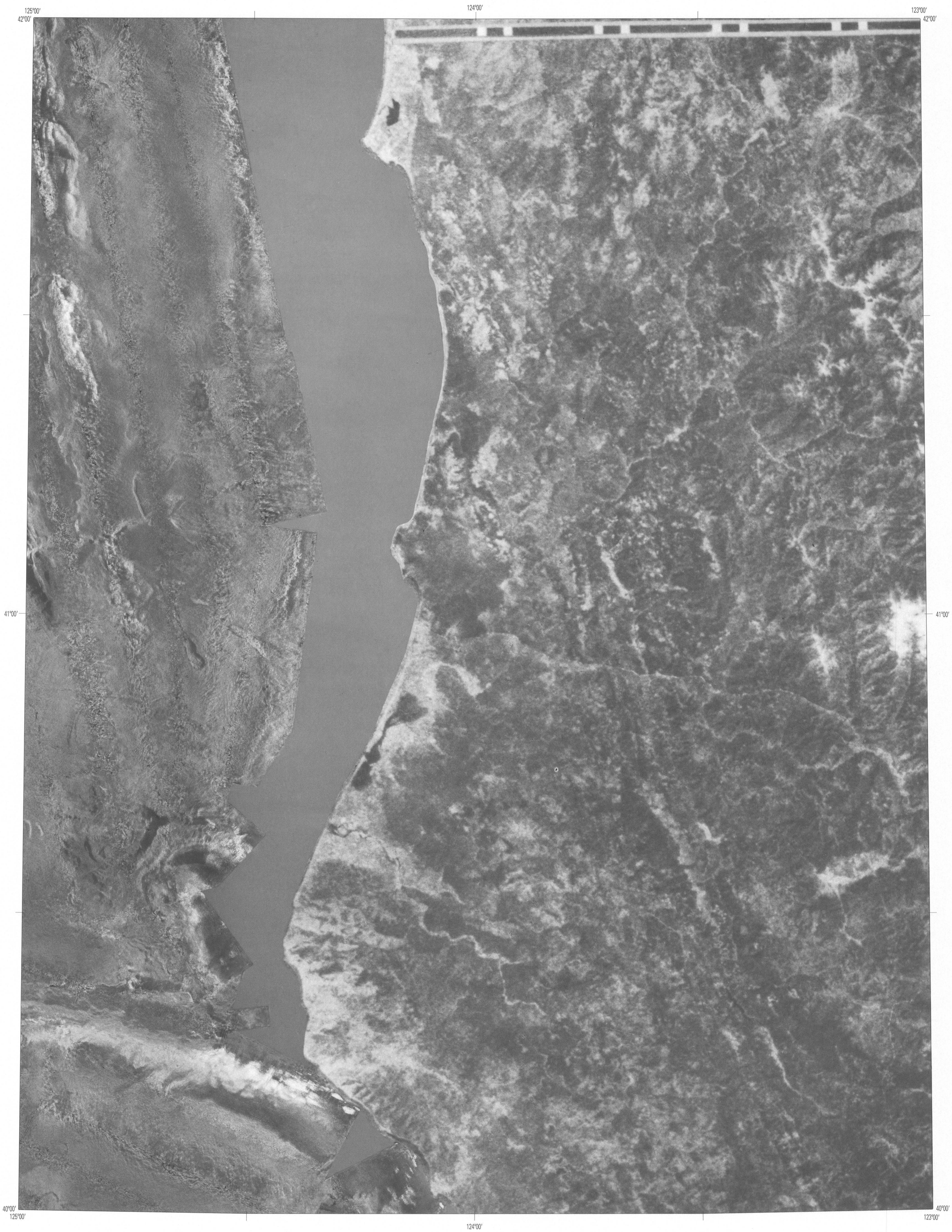
10 0 10 20 30 40 50 KILOMETERS

TRANSVERSE MERCATOR PROJECTION

1 centimeter equals 5 kilometers

SHEET LOCATION

BATHYMETRIC CONTOUR INTERVAL 100 METERS



NO DATA

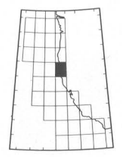
SCALE 1:500,000

10 0 10 20 30 NAUTICAL MILES

10 0 10 20 30 40 50 KILOMETERS

TRANSVERSE MERCATOR PROJECTION

1 centimeter equals 5 kilometers



SHEET LOCATION

GEOLOGIC INTERPRETATION
SHEET 20
BATHYMETRY



Base from National Ocean Survey (1969), Map 1308N–12

NO DATA

SCALE 1:500,000

10 0 10 20 30 NAUTICAL MILES

10 0 10 20 30 40 50 KILOMETERS

TRANSVERSE MERCATOR PROJECTION

1 centimeter equals 5 kilometers

SHEET LOCATION

BATHYMETRIC CONTOUR INTERVAL 100 METERS



NO DATA

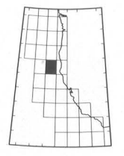
SCALE 1:500,000

10 0 10 20 30 NAUTICAL MILES

10 0 10 20 30 40 50 KILOMETERS

TRANSVERSE MERCATOR PROJECTION

1 centimeter equals 5 kilometers



SHEET LOCATION



Base from Chase and others (1981)

Base from National Ocean Survey (1969), Map 1308N–12

NO DATA

SCALE 1:500,000

10 0 10 20 30 NAUTICAL MILES

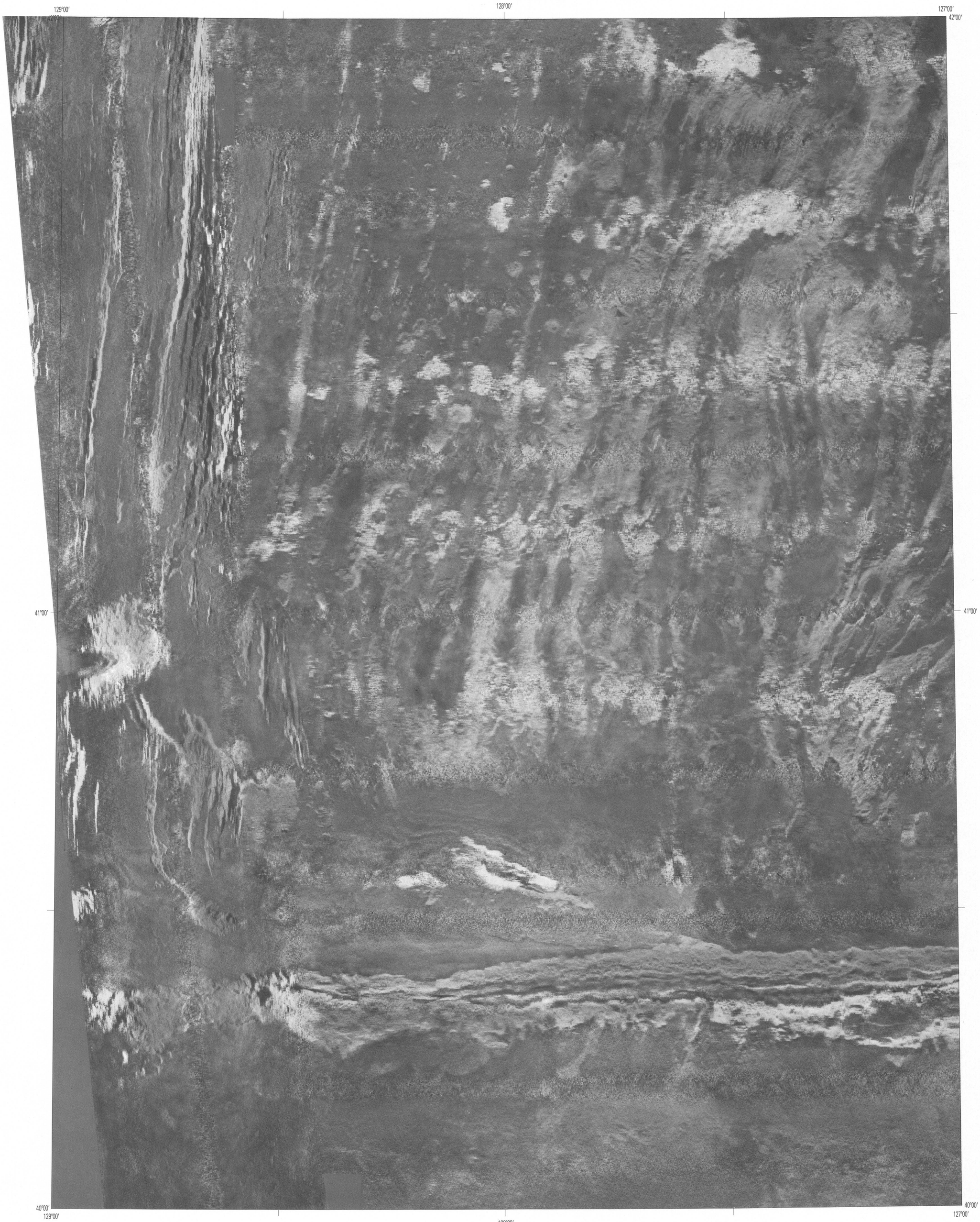
10 0 10 20 30 40 50 KILOMETERS

TRANSVERSE MERCATOR PROJECTION

1 centimeter equals 5 kilometers

SHEET LOCATION

BATHYMETRIC CONTOUR INTERVAL 100 METERS



NO DATA

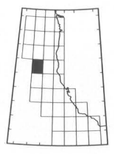
SCALE 1:500,000

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10 0 10 20 30 40 50 KILOMETERS

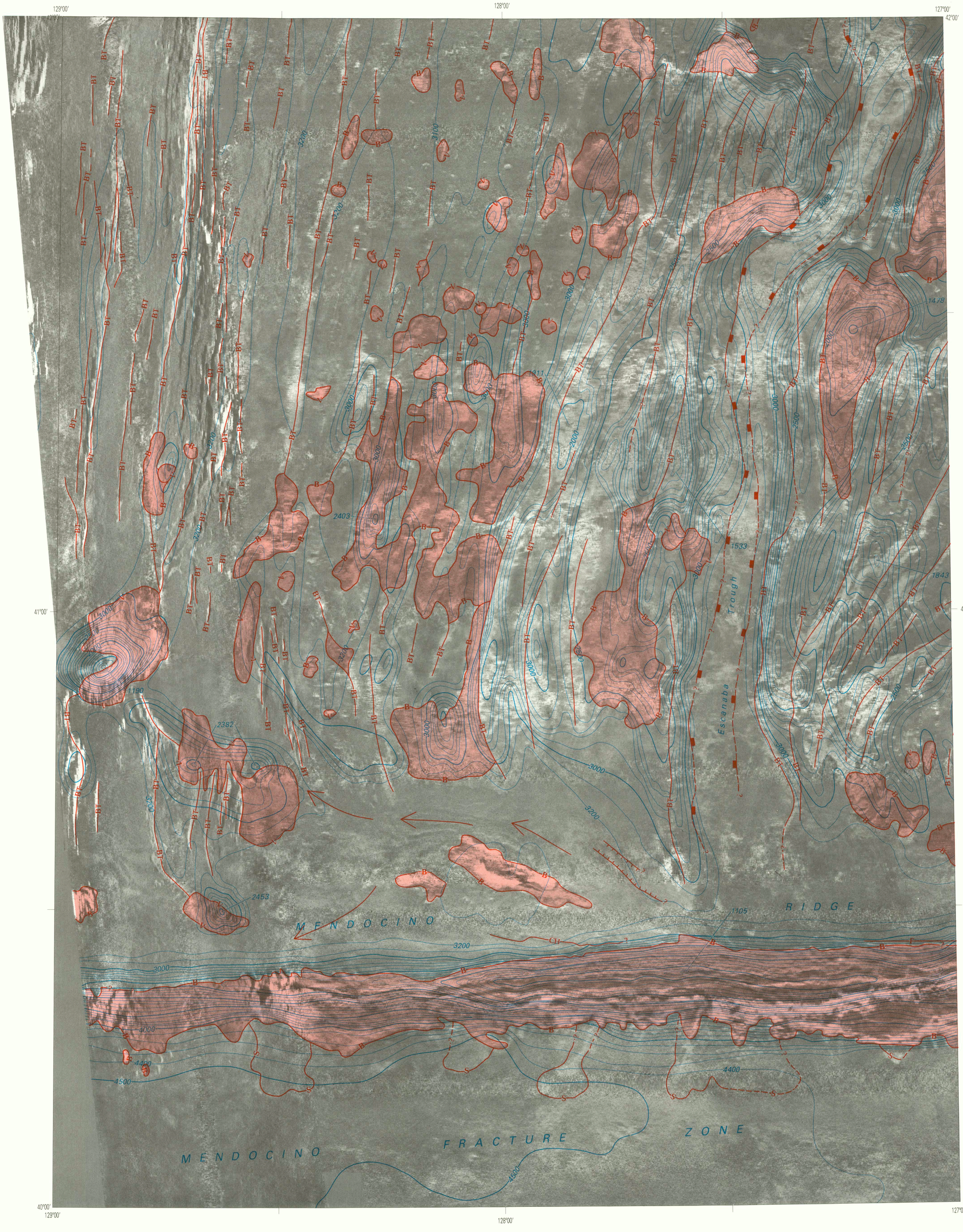
TRANSVERSE MERCATOR PROJECTION

1 centimeter equals 5 kilometers



SHEET LOCATION

GEOLOGIC INTERPRETATION
SHEET 22
BATHYMETRY



Base from Chase and others (1981)

NO DATA

SCALE 1:500,000

10 0 10 20 30 NAUTICAL MILES

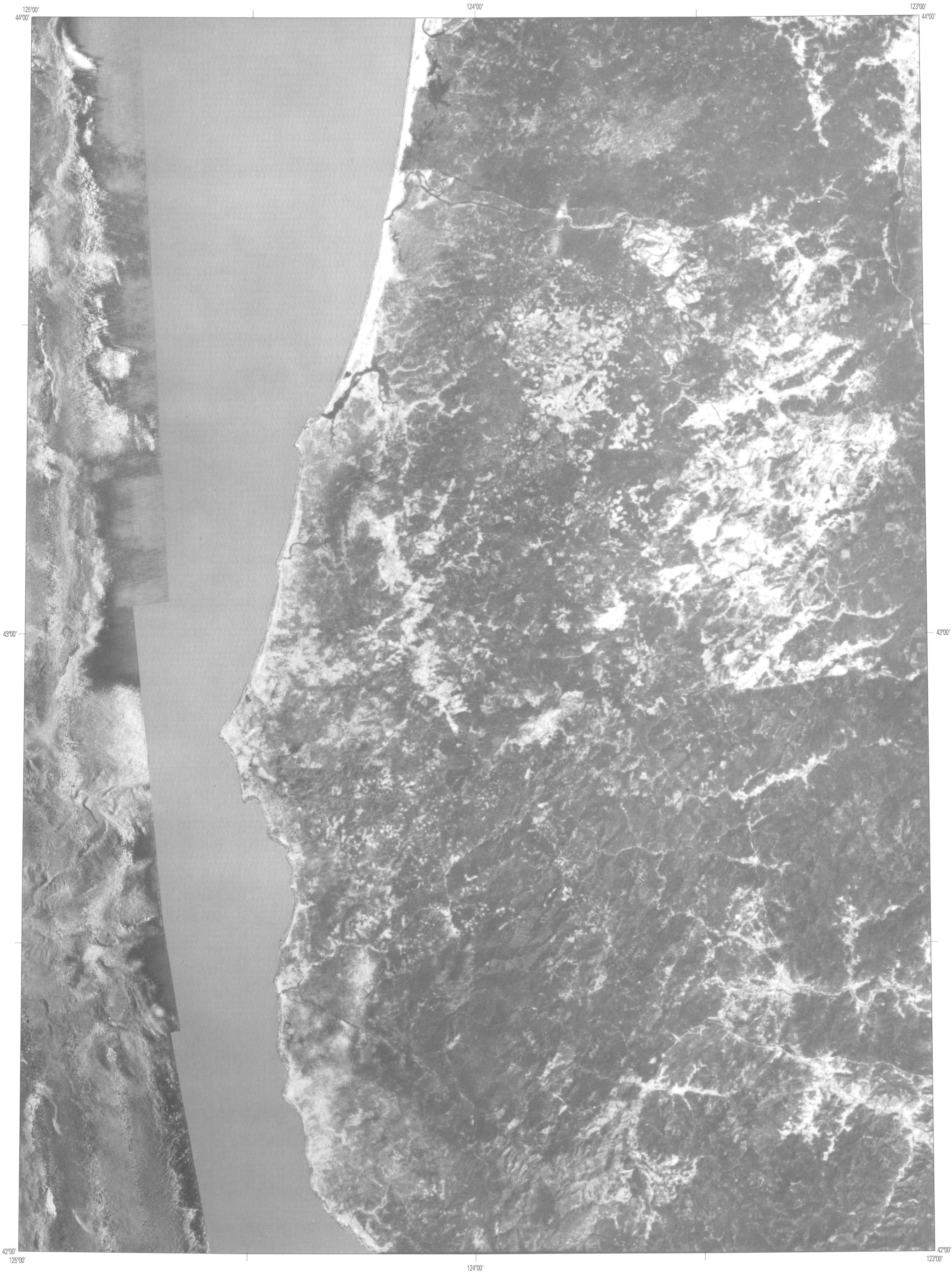
10 0 10 20 30 40 50 KILOMETERS

TRANSVERSE MERCATOR PROJECTION

1 centimeter equals 5 kilometers

SHEET LOCATION

BATHYMETRIC CONTOUR INTERVAL 100 METERS



NO DATA

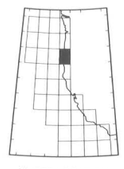
SCALE 1:500,000

10 0 10 20 30 NAUTICAL MILES

10 0 10 20 30 40 50 KILOMETERS

TRANSVERSE MERCATOR PROJECTION

1 centimeter equals 5 kilometers



SHEET LOCATION

GEOLOGIC INTERPRETATION
SHEET 23
BATHYMETRY



Base from National Ocean Survey (1968b), Map 1308N-17

NO DATA

SCALE 1:500,000

10 0 10 20 30 NAUTICAL MILES

10 0 10 20 30 40 50 KILOMETERS

TRANSVERSE MERCATOR PROJECTION

1 centimeter equals 5 kilometers

SHEET LOCATION

BATHYMETRIC CONTOUR INTERVAL 100 METERS

DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

SONAR MOSAIC
SHEET 24

ATLAS OF THE EXCLUSIVE ECONOMIC ZONE
WESTERN CONTERMINOUS UNITED STATES
I–1792



NO DATA

SCALE 1:500,000

10 0 10 20 30 NAUTICAL MILES

10 0 10 20 30 40 50 KILOMETERS

TRANSVERSE MERCATOR PROJECTION

1 centimeter equals 5 kilometers



SHEET LOCATION

GEOLOGIC INTERPRETATION
SHEET 24
BATHYMETRY



Base from National Ocean Survey (1974c), 12042–12 B

Base from National Ocean Survey (1968b), Map 1308N–17

NO DATA

SCALE 1:500,000

10 0 10 20 30 NAUTICAL MILES

10 0 10 20 30 40 50 KILOMETERS

TRANSVERSE MERCATOR PROJECTION

1 centimeter equals 5 kilometers



SHEET LOCATION

BATHYMETRIC CONTOUR INTERVAL 100 METERS



NO DATA

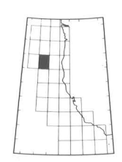
SCALE 1:500,000

10 0 10 20 30 NAUTICAL MILES

10 0 10 20 30 40 50 KILOMETERS

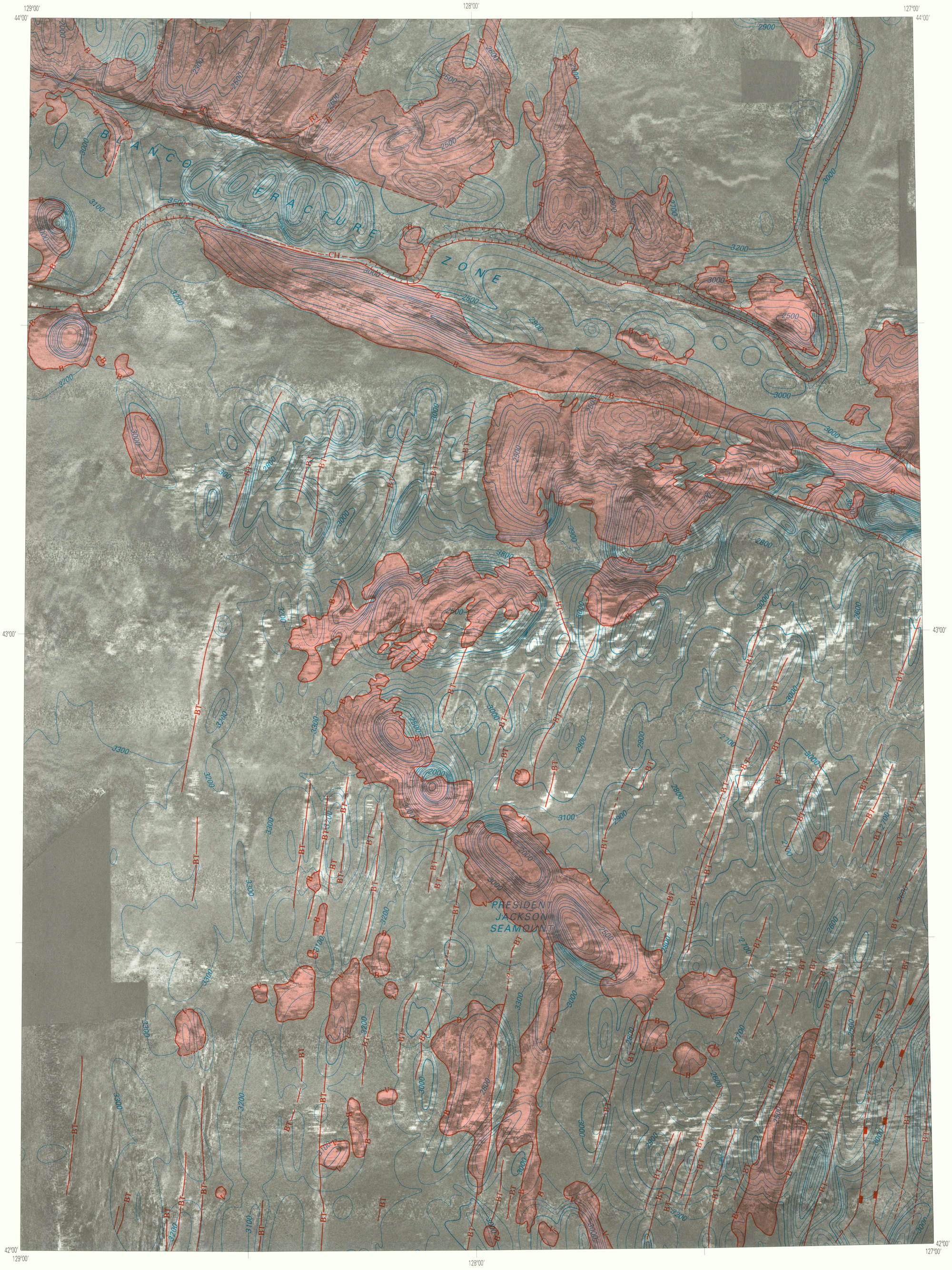
TRANSVERSE MERCATOR PROJECTION

1 centimeter equals 5 kilometers



SHEET LOCATION

GEOLOGIC INTERPRETATION
SHEET 25
BATHYMETRY



Base from National Ocean Survey (1974c), 12042–12B

NO DATA

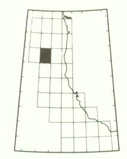
SCALE 1:500,000

10 0 10 20 30 NAUTICAL MILES

10 0 10 20 30 40 50 KILOMETERS

TRANSVERSE MERCATOR PROJECTION

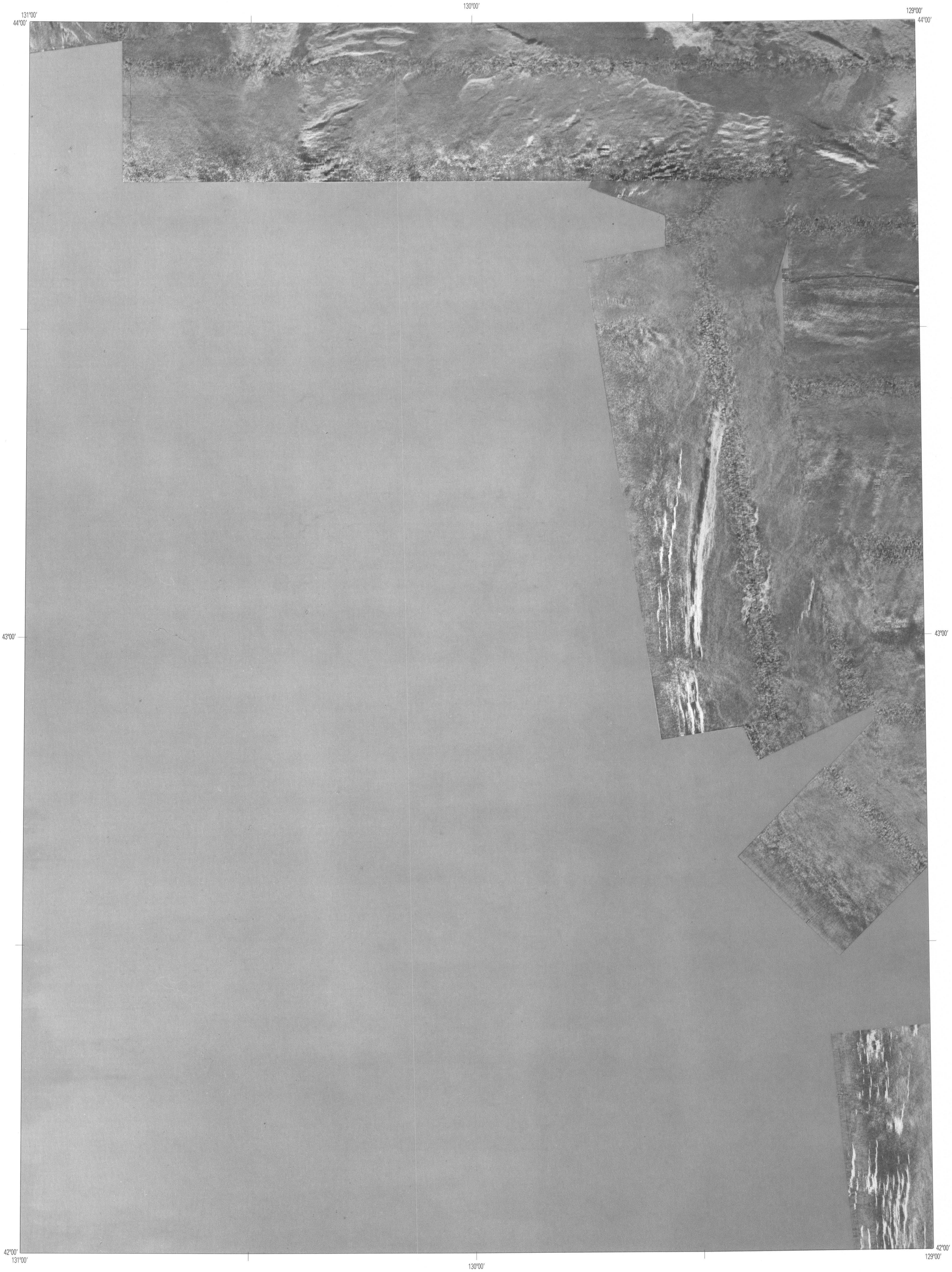
1 centimeter equals 5 kilometers



SHEET LOCATION

BATHYMETRIC CONTOUR INTERVAL 100 METERS

SONAR MOSAIC
SHEET 26



NO DATA

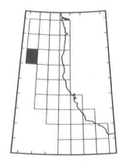
SCALE 1:500,000

10 0 10 20 30 NAUTICAL MILES

10 0 10 20 30 40 50 KILOMETERS

TRANSVERSE MERCATOR PROJECTION

1 centimeter equals 5 kilometers



SHEET LOCATION

DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

GEOLOGIC INTERPRETATION
SHEET 26
BATHYMETRY

ATLAS OF THE EXCLUSIVE ECONOMIC ZONE
WESTERN CONTERMINOUS UNITED STATES
I-1792



Base from National Ocean Survey (1974c), 12042–12B

NO DATA

SCALE 1:500,000

10 0 10 20 30 NAUTICAL MILES

10 0 10 20 30 40 50 KILOMETERS

TRANSVERSE MERCATOR PROJECTION

1 centimeter equals 5 kilometers

SHEET LOCATION

BATHYMETRIC CONTOUR INTERVAL 100 METERS



NO DATA

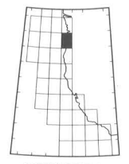
SCALE 1:500,000

10 0 10 20 30 NAUTICAL MILES

10 0 10 20 30 40 50 KILOMETERS

TRANSVERSE MERCATOR PROJECTION

1 centimeter equals 5 kilometers



SHEET LOCATION

GEOLOGIC INTERPRETATION
SHEET 27
BATHYMETRY



Base from National Ocean Survey (1968), Map 1308N–22

NO DATA

SCALE 1:500,000

10 0 10 20 30 NAUTICAL MILES

10 0 10 20 30 40 50 KILOMETERS

TRANSVERSE MERCATOR PROJECTION

1 centimeter equals 5 kilometers

BATHYMETRIC CONTOUR INTERVAL 100 METERS

SHEET LOCATION



NO DATA

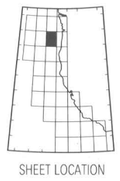
SCALE 1:500,000

10 0 10 20 30 NAUTICAL MILES

10 0 10 20 30 40 50 KILOMETERS

TRANSVERSE MERCATOR PROJECTION

1 centimeter equals 5 kilometers



SHEET LOCATION

GEOLOGIC INTERPRETATION
SHEET 28
BATHYMETRY



Base from National Ocean Survey (1974c), 12042–12B

Base from National Ocean Survey (1968a), Map 1308N–22

NO DATA

SCALE 1:500,000

10 0 10 20 30 NAUTICAL MILES

10 0 10 20 30 40 50 KILOMETERS

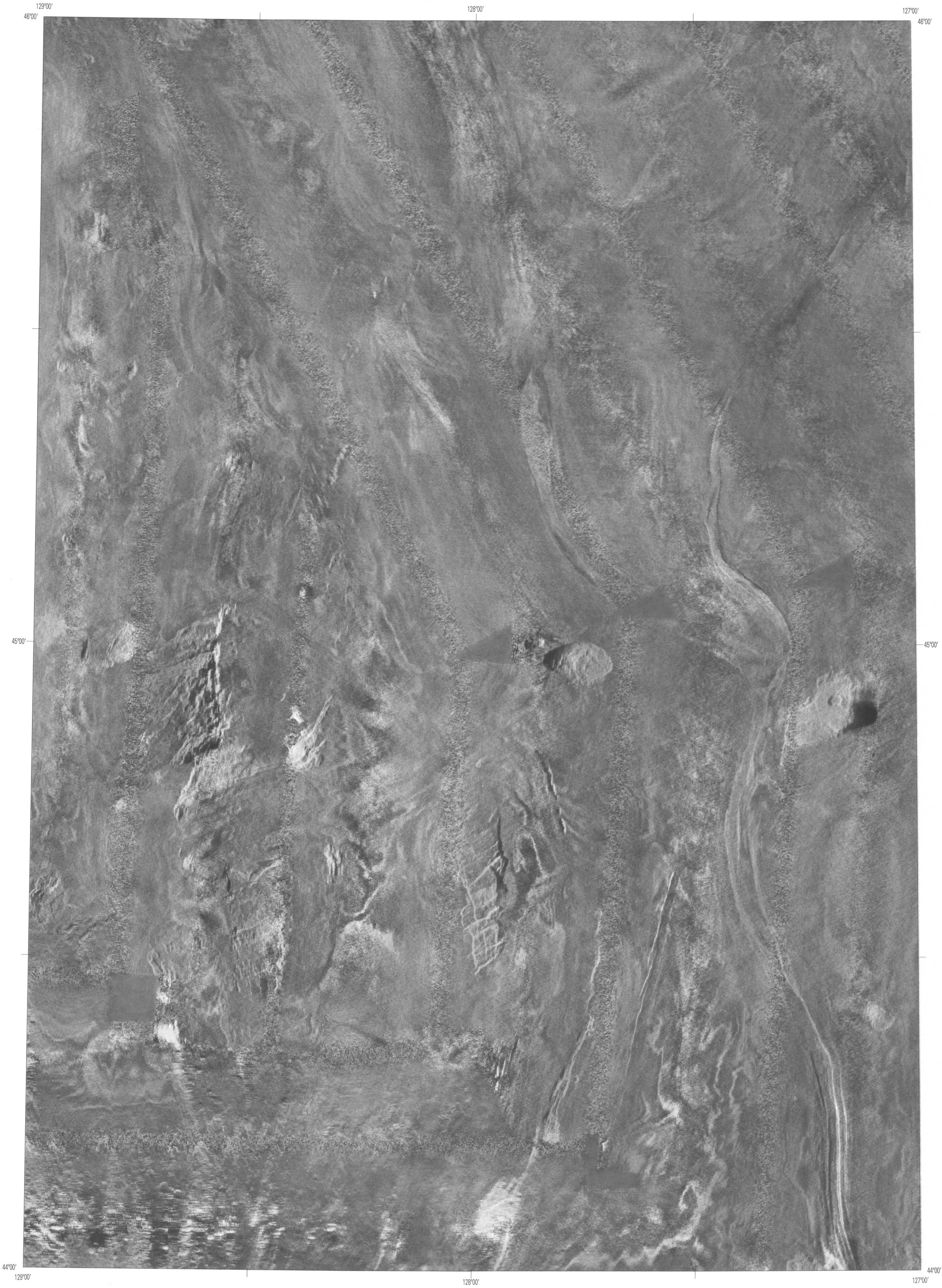
TRANSVERSE MERCATOR PROJECTION

1 centimeter equals 5 kilometers

BATHYMETRIC CONTOUR INTERVAL 100 METERS

SHEET LOCATION

SONAR MOSAIC
SHEET 29



NO DATA

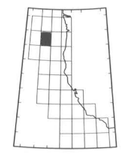
SCALE 1:500,000

10 0 10 20 30 NAUTICAL MILES

10 0 10 20 30 40 50 KILOMETERS

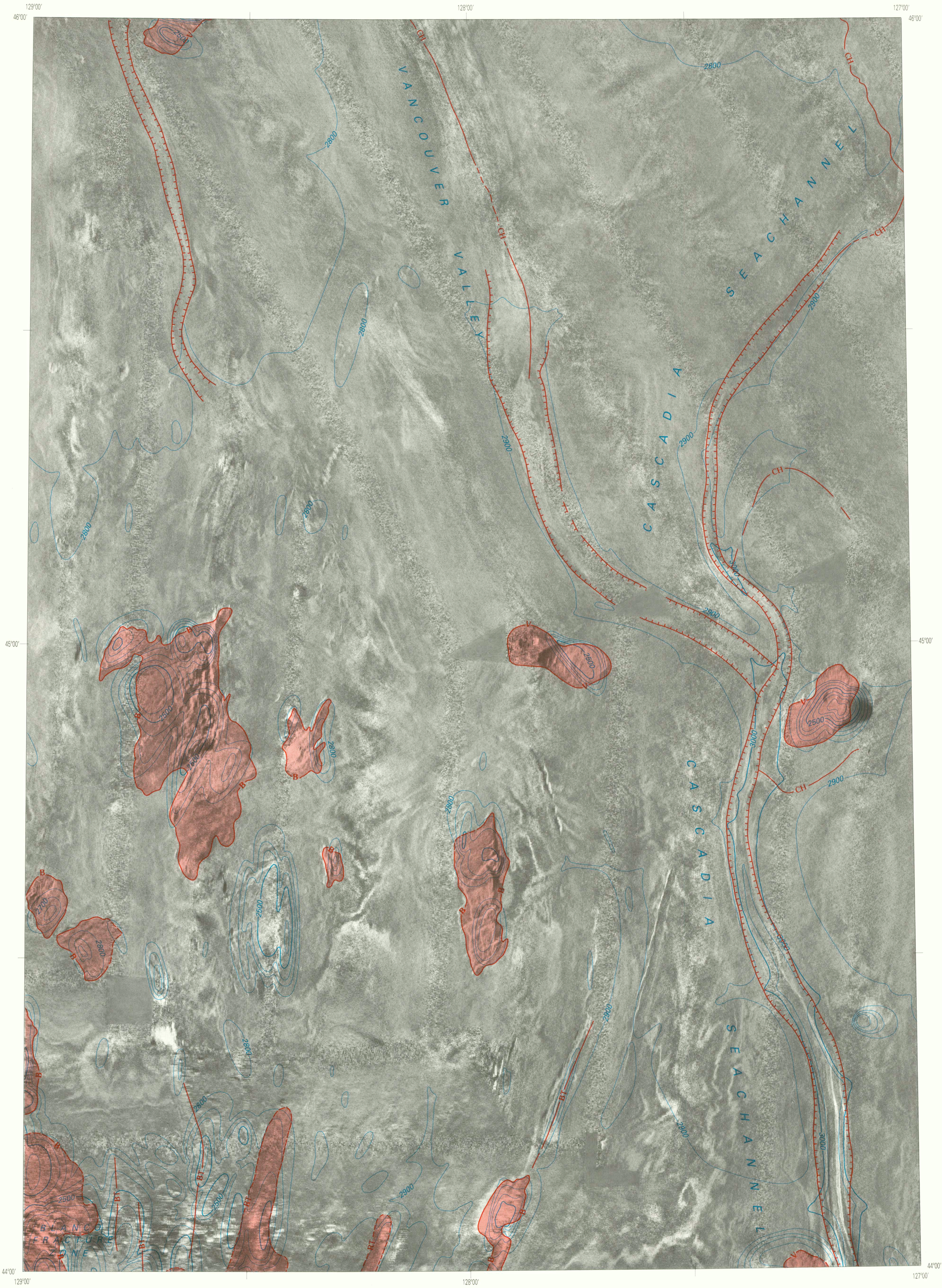
TRANSVERSE MERCATOR PROJECTION

1 centimeter equals 5 kilometers



SHEET LOCATION

GEOLOGIC INTERPRETATION
SHEET 29
BATHYMETRY



Base from National Ocean Survey (1974c), 12042–12B

NO DATA

SCALE 1:500,000

10 0 10 20 30 NAUTICAL MILES

10 0 10 20 30 40 50 KILOMETERS

TRANSVERSE MERCATOR PROJECTION

1 centimeter equals 5 kilometers

SHEET LOCATION

BATHYMETRIC CONTOUR INTERVAL 100 METERS

131°00′
130°00′
129°00′
46°00′
45°00′
44°00′

NO DATA

SCALE 1:500,000

10 0 10 20 30 NAUTICAL MILES

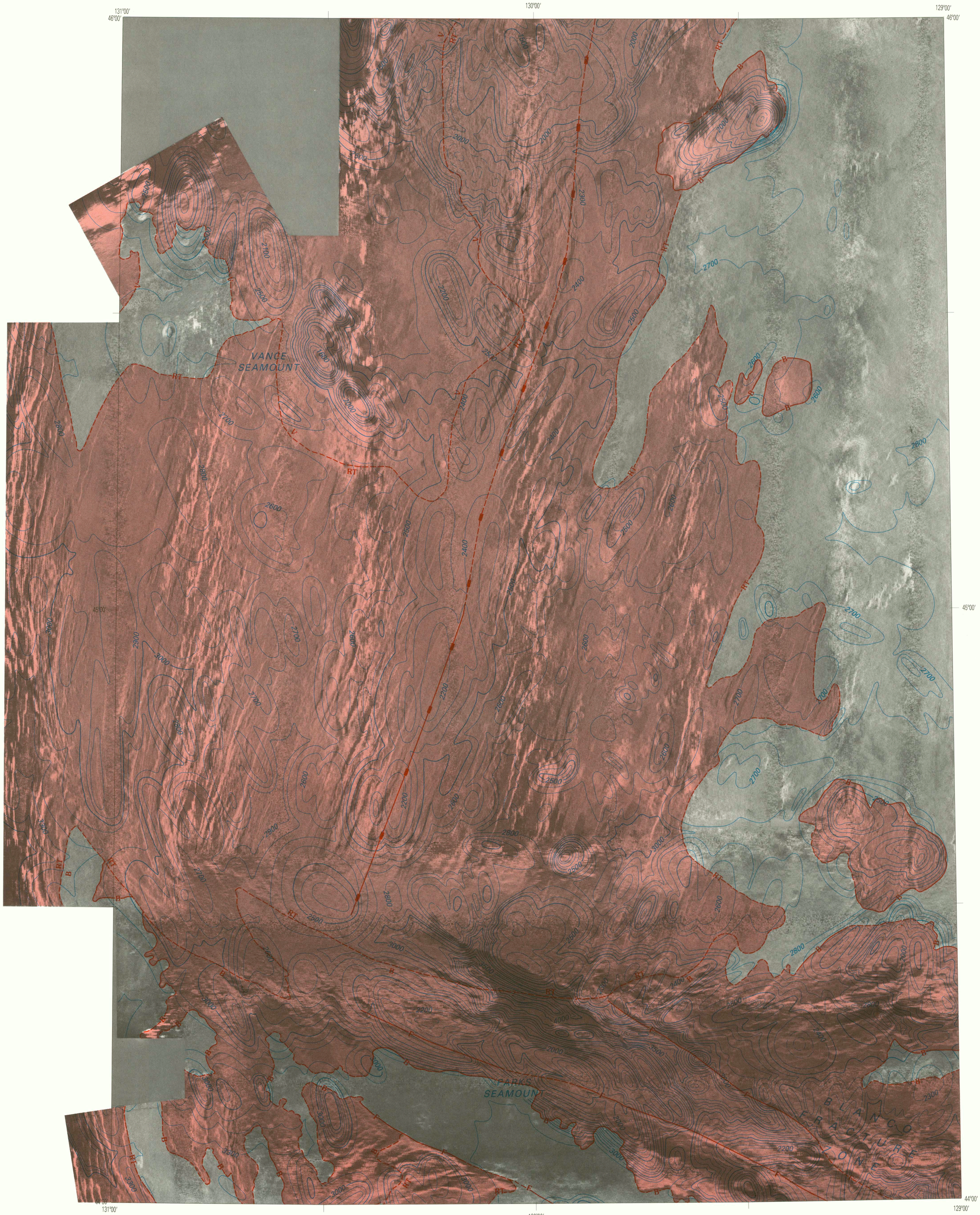
10 0 10 20 30 40 50 KILOMETERS

TRANSVERSE MERCATOR PROJECTION

1 centimeter equals 5 kilometers

SHEET LOCATION

GEOLOGIC INTERPRETATION
SHEET 30
BATHYMETRY



Base from National Ocean Survey (1974c), 12042–12B

NO DATA

SCALE 1:500,000

10 0 10 20 30 NAUTICAL MILES

10 0 10 20 30 40 50 KILOMETERS

TRANSVERSE MERCATOR PROJECTION

1 centimeter equals 5 kilometers

SHEET LOCATION

BATHYMETRIC CONTOUR INTERVAL 100 METERS



NO DATA

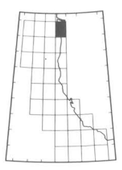
SCALE 1:500,000

10 0 10 20 30 NAUTICAL MILES

10 0 10 20 30 40 50 KILOMETERS

TRANSVERSE MERCATOR PROJECTION

1 centimeter equals 5 kilometers



SHEET LOCATION

GEOLOGIC INTERPRETATION
SHEET 31
BATHYMETRY



Base from National Ocean Survey (1974c), 12042–12B

NO DATA

SCALE 1:500,000

10 0 10 20 30 NAUTICAL MILES

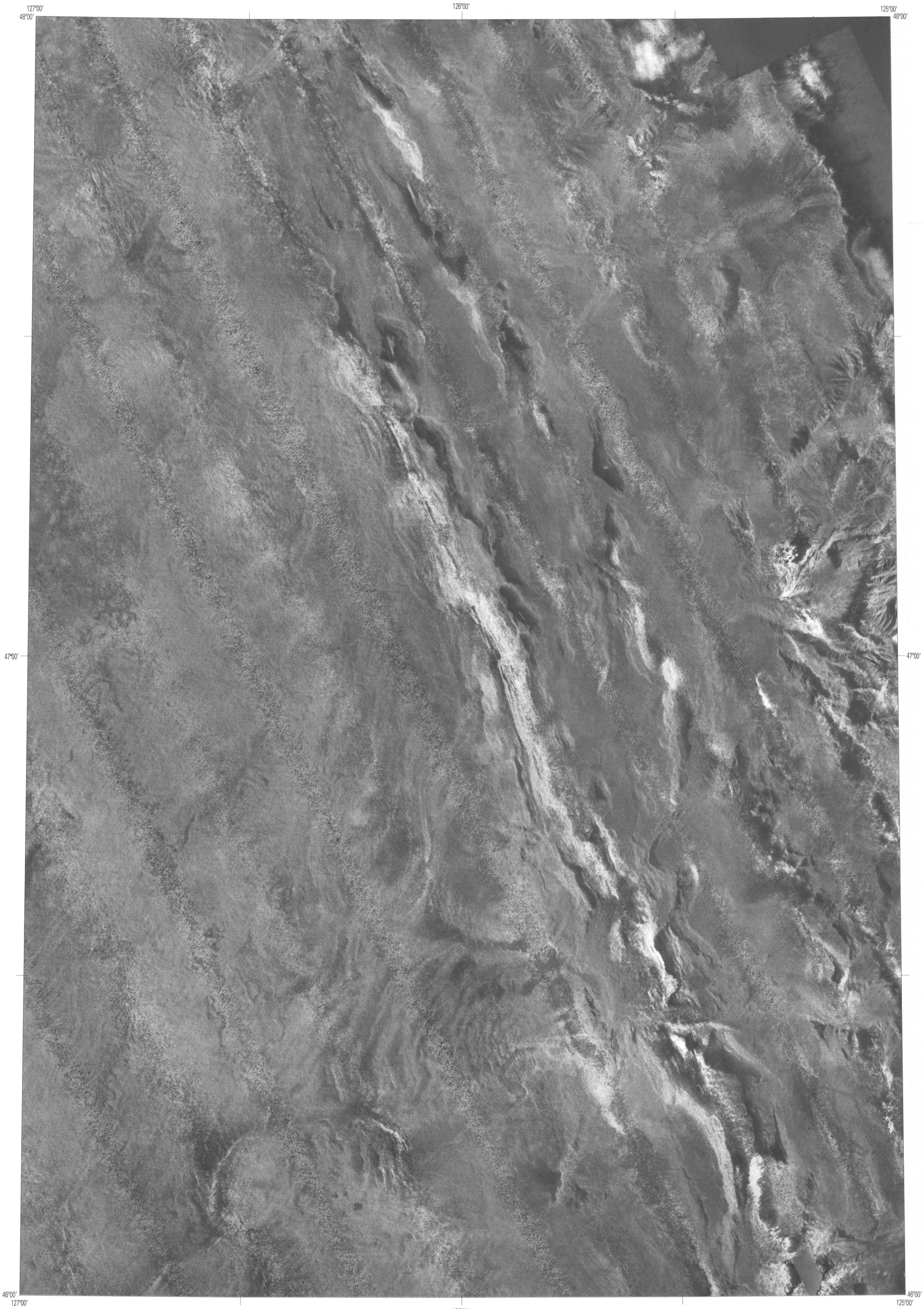
10 0 10 20 30 40 50 KILOMETERS

TRANSVERSE MERCATOR PROJECTION

1 centimeter equals 5 kilometers

SHEET LOCATION

BATHYMETRIC CONTOUR INTERVAL 100 METERS



NO DATA

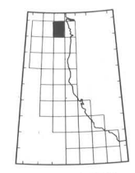
SCALE 1:500,000

10 0 10 20 30 NAUTICAL MILES

10 0 10 20 30 40 50 KILOMETERS

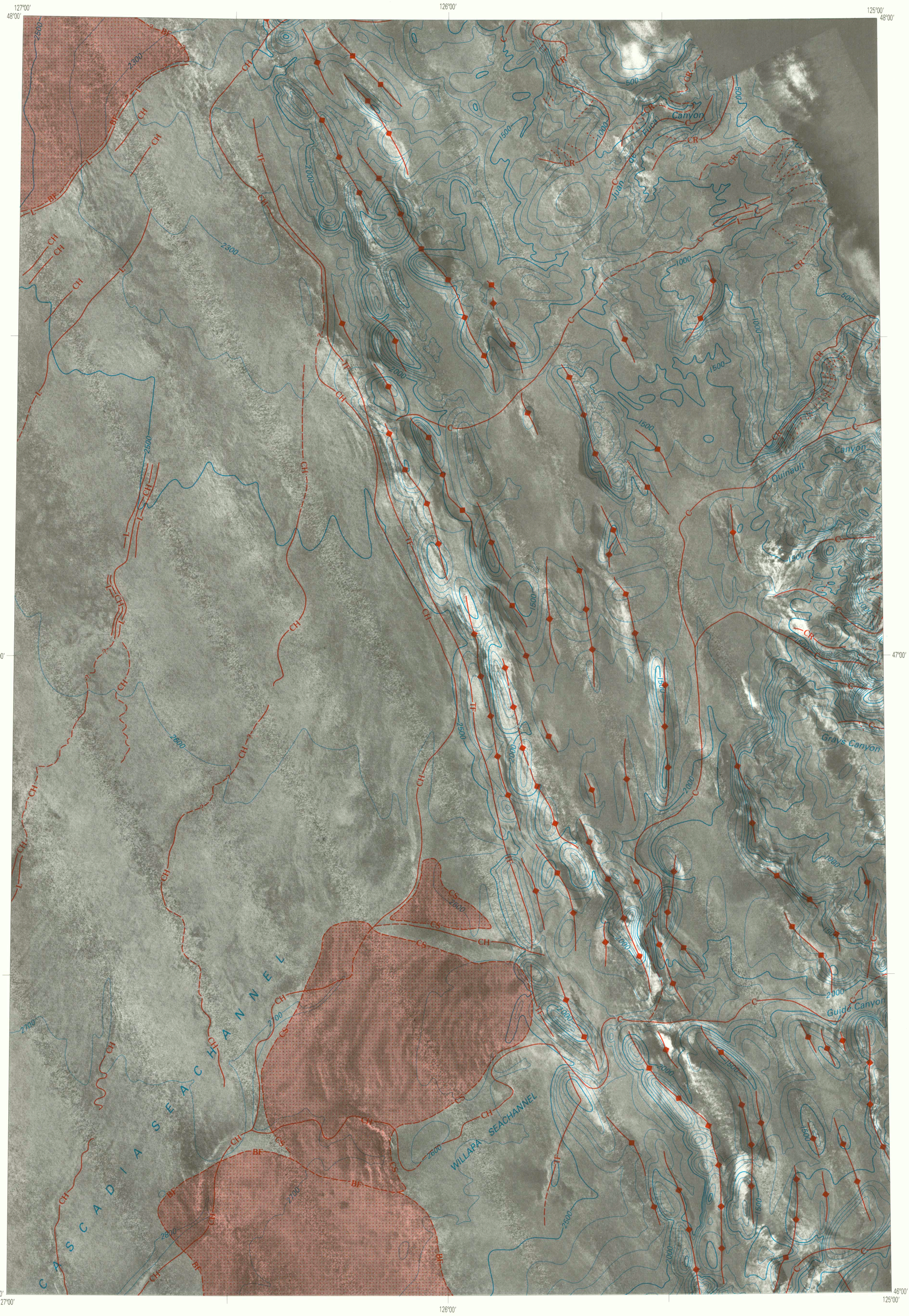
TRANSVERSE MERCATOR PROJECTION

1 centimeter equals 5 kilometers



SHEET LOCATION

GEOLOGIC INTERPRETATION
SHEET 32
BATHYMETRY



Base from National Ocean Survey (1974c), 12042–12B

NO DATA

SCALE 1:500,000

10 0 10 20 30 NAUTICAL MILES

10 0 10 20 30 40 50 KILOMETERS

TRANSVERSE MERCATOR PROJECTION

1 centimeter equals 5 kilometers

SHEET LOCATION

BATHYMETRIC CONTOUR INTERVAL 100 METERS

DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

SONAR MOSAIC
SHEET 33

ATLAS OF THE EXCLUSIVE ECONOMIC ZONE
WESTERN CONTERMINOUS UNITED STATES
I–1792



NO DATA

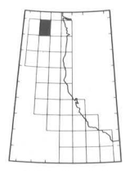
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10 0 10 20 30 40 50 KILOMETERS

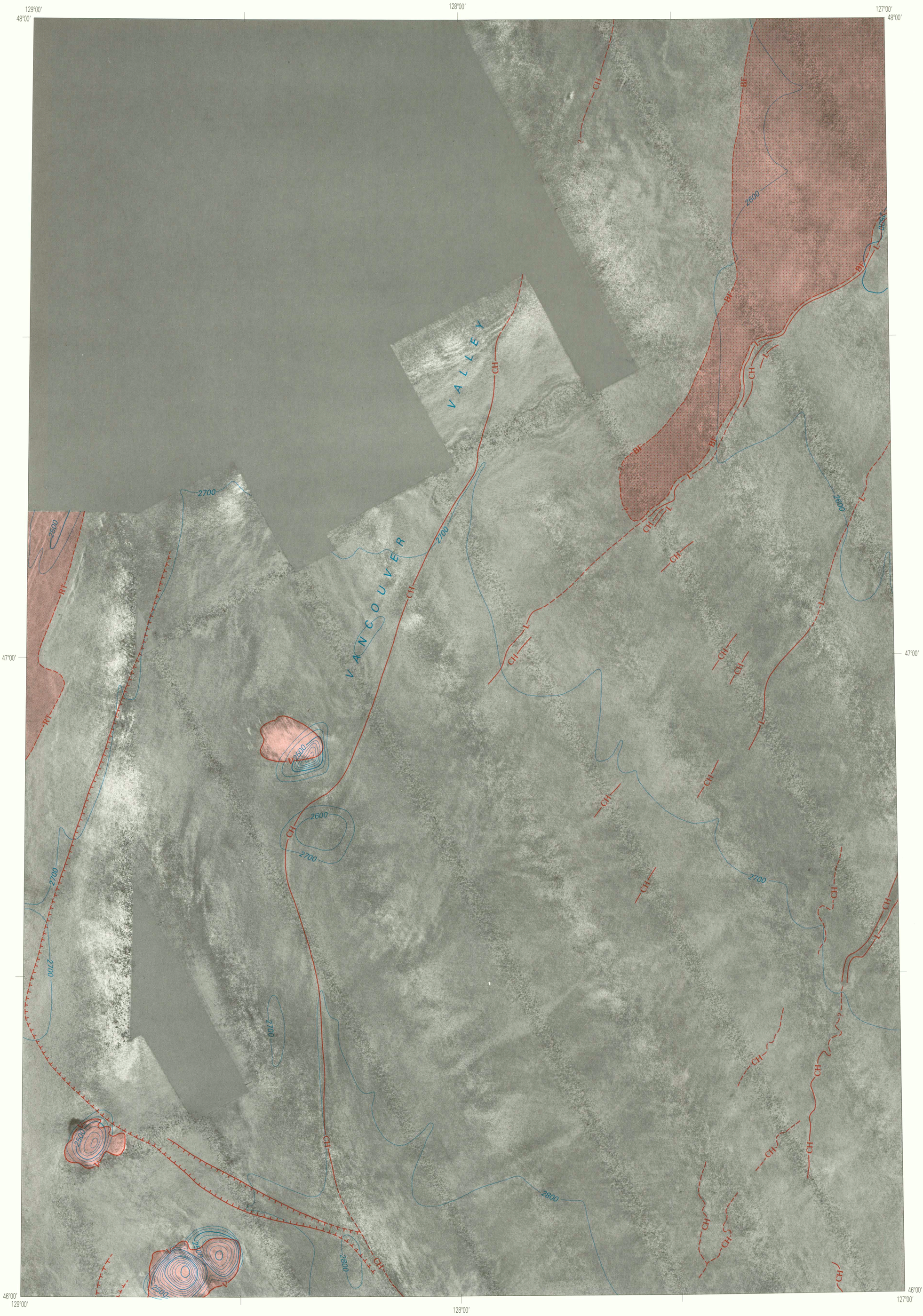
TRANSVERSE MERCATOR PROJECTION

1 centimeter equals 5 kilometers



SHEET LOCATION

GEOLOGIC INTERPRETATION
SHEET 33
BATHYMETRY



Base from National Ocean Survey (1974c), 12042–12B

NO DATA

SCALE 1:500,000

10 0 10 20 30 NAUTICAL MILES

10 0 10 20 30 40 50 KILOMETERS

TRANSVERSE MERCATOR PROJECTION

1 centimeter equals 5 kilometers

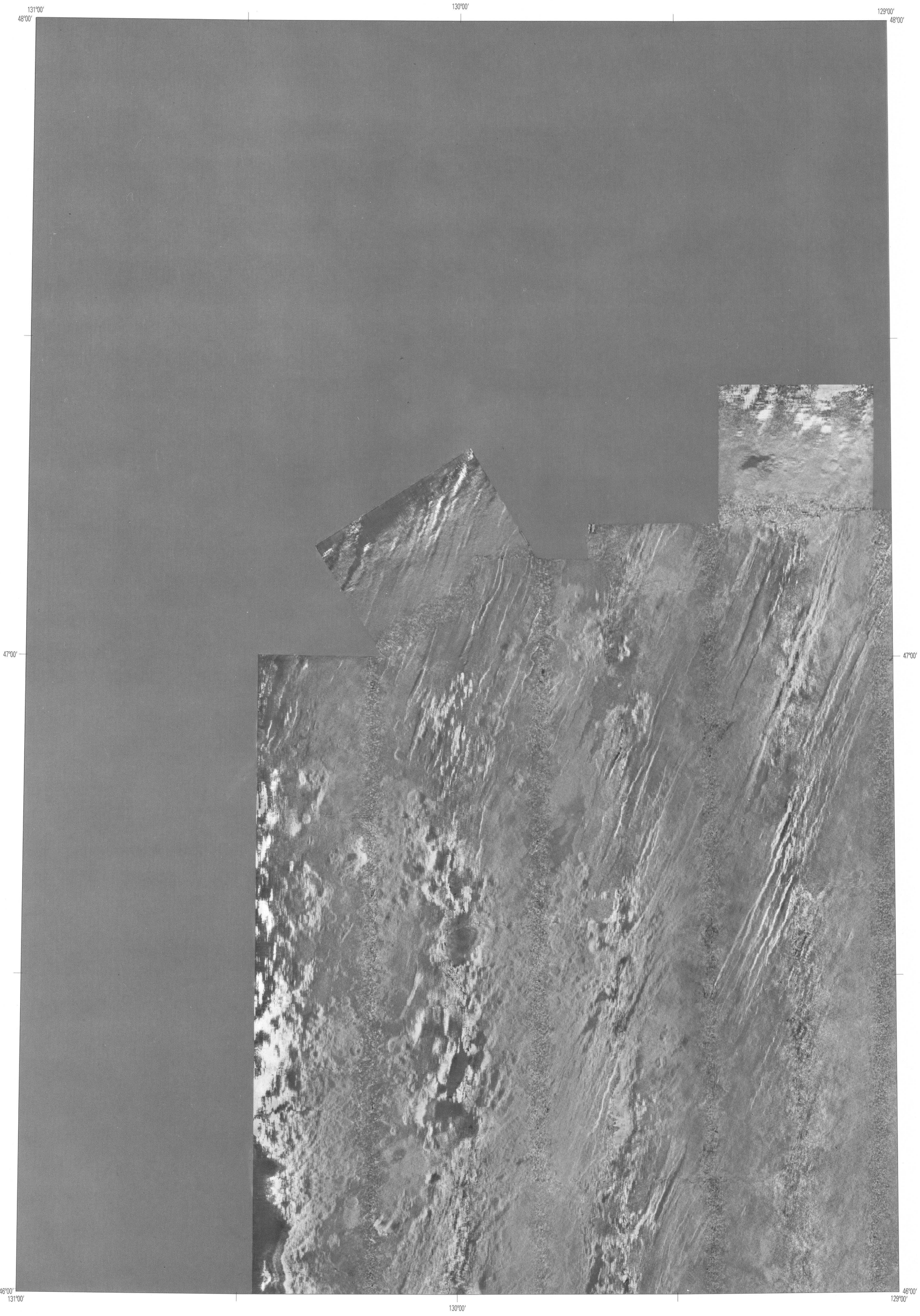
SHEET LOCATION

BATHYMETRIC CONTOUR INTERVAL 100 METERS

DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

SONAR MOSAIC
SHEET 34

ATLAS OF THE EXCLUSIVE ECONOMIC ZONE
WESTERN CONTERMINOUS UNITED STATES
I-1792



NO DATA

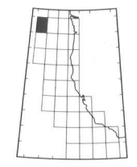
SCALE 1:500,000

10 0 10 20 30 NAUTICAL MILES

10 0 10 20 30 40 50 KILOMETERS

TRANSVERSE MERCATOR PROJECTION

1 centimeter equals 5 kilometers

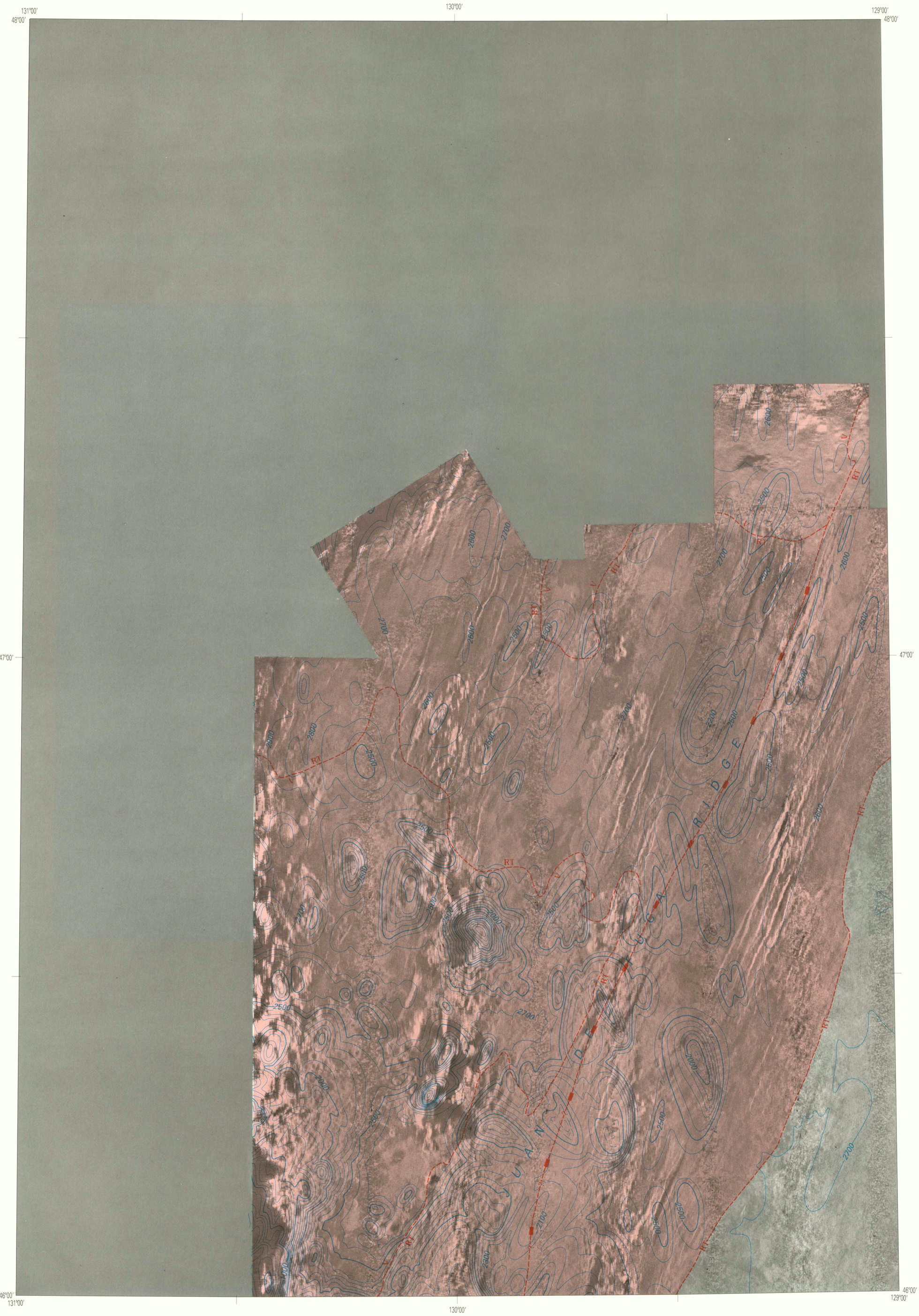


SHEET LOCATION

DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

GEOLOGIC INTERPRETATION
SHEET 34
BATHYMETRY

ATLAS OF THE EXCLUSIVE ECONOMIC ZONE
WESTERN CONTERMINOUS UNITED STATES
I-1792



Base from National Ocean Survey (1974c), 12042–12B

NO DATA

SCALE 1:500,000

10 0 10 20 30 NAUTICAL MILES

10 0 10 20 30 40 50 KILOMETERS

TRANSVERSE MERCATOR PROJECTION

1 centimeter equals 5 kilometers

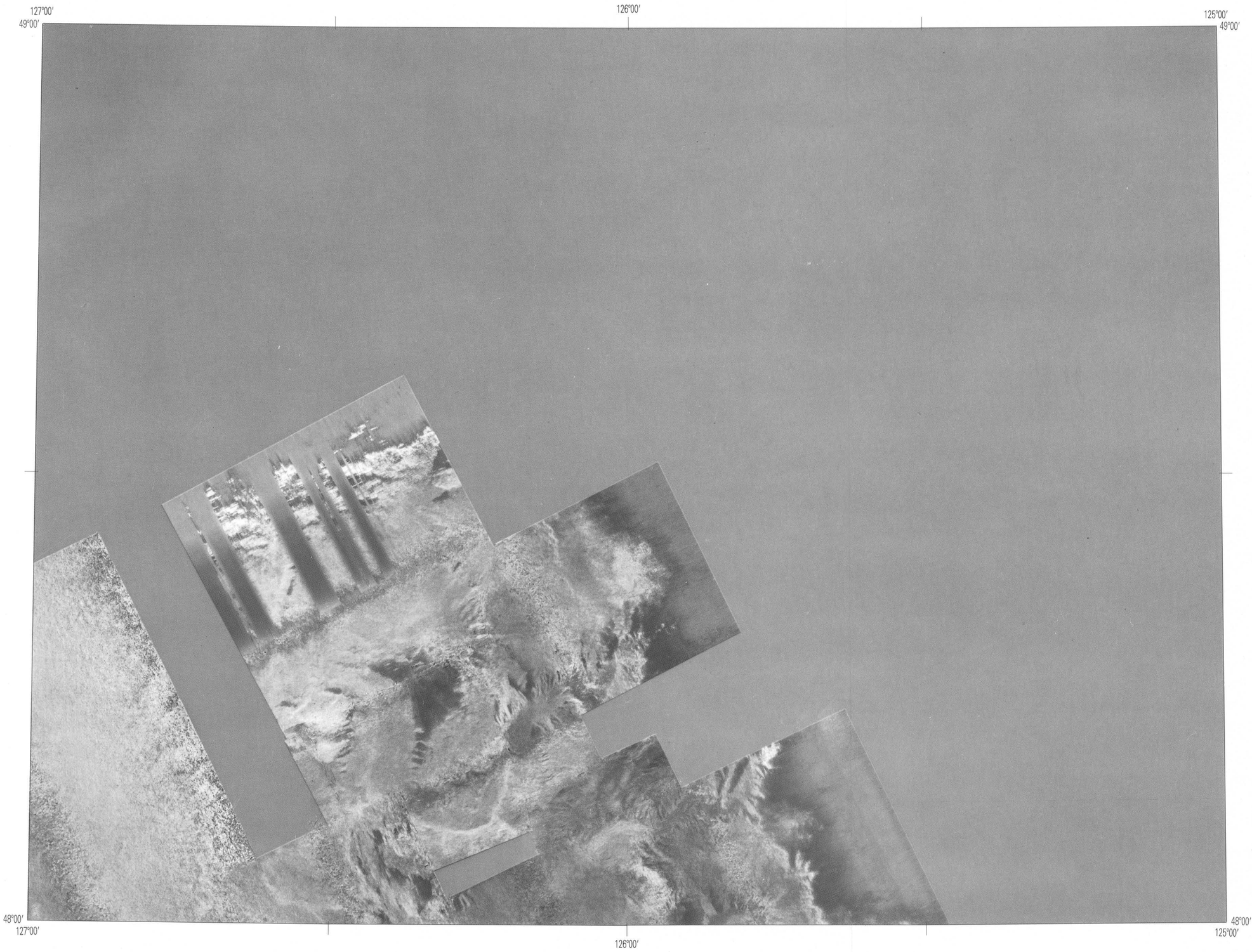
SHEET LOCATION

BATHYMETRIC CONTOUR INTERVAL 100 METERS

DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

SONAR MOSAIC
SHEET 35

ATLAS OF THE EXCLUSIVE ECONOMIC ZONE
WESTERN CONTERMINOUS UNITED STATES
I-1792



NO DATA

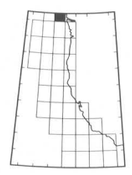
SCALE 1:500,000

10 0 10 20 30 NAUTICAL MILES

10 0 10 20 30 40 50 KILOMETERS

TRANSVERSE MERCATOR PROJECTION

1 centimeter equals 5 kilometers

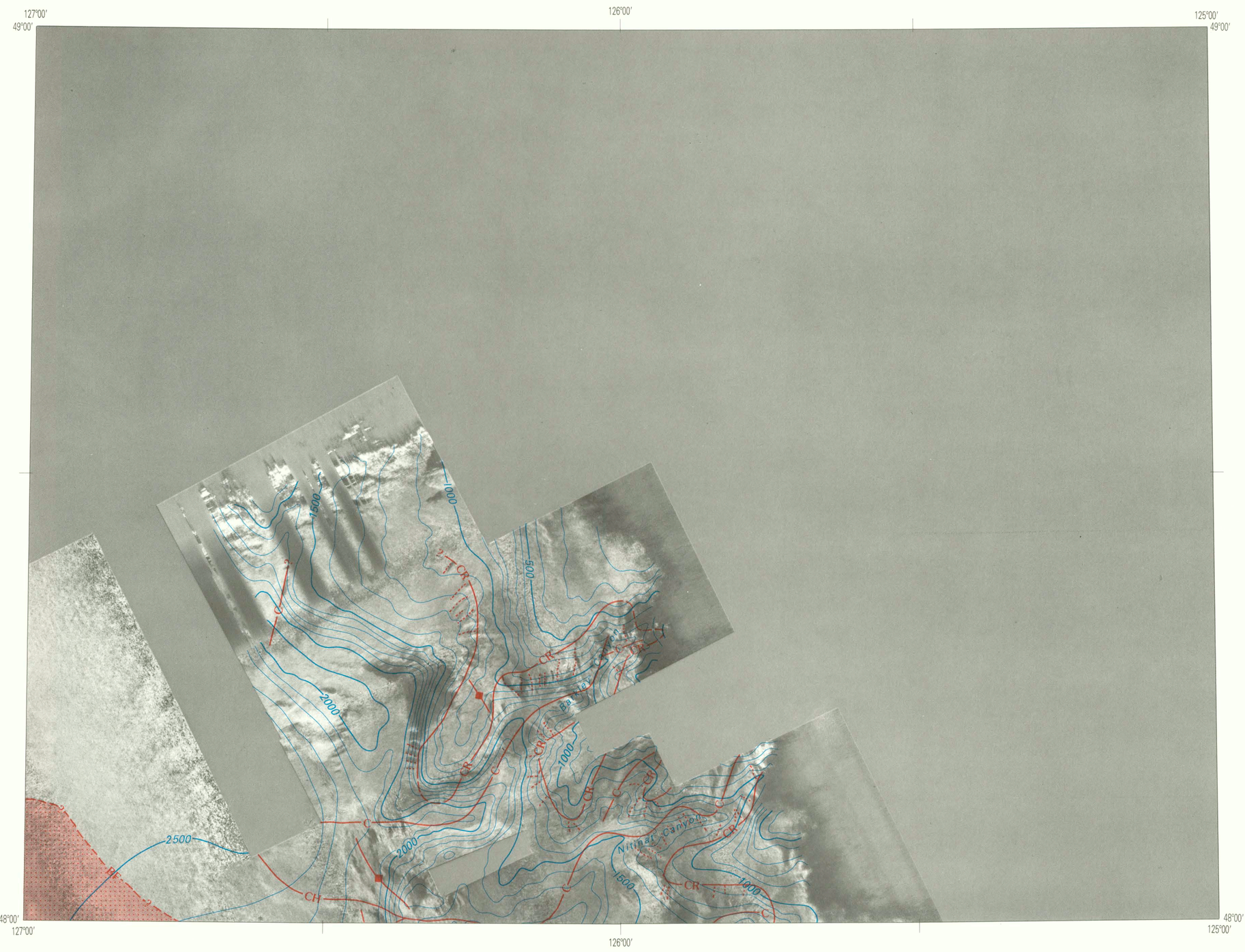


SHEET LOCATION

DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

GEOLOGIC INTERPRETATION
SHEET 35
BATHYMETRY

ATLAS OF THE EXCLUSIVE ECONOMIC ZONE
WESTERN CONTERMINOUS UNITED STATES
I-1792



Base from Chase and others (1981)

NO DATA

SCALE 1:500,000

10 0 10 20 30 NAUTICAL MILES

10 0 10 20 30 40 50 KILOMETERS

TRANSVERSE MERCATOR PROJECTION

1 centimeter equals 5 kilometers



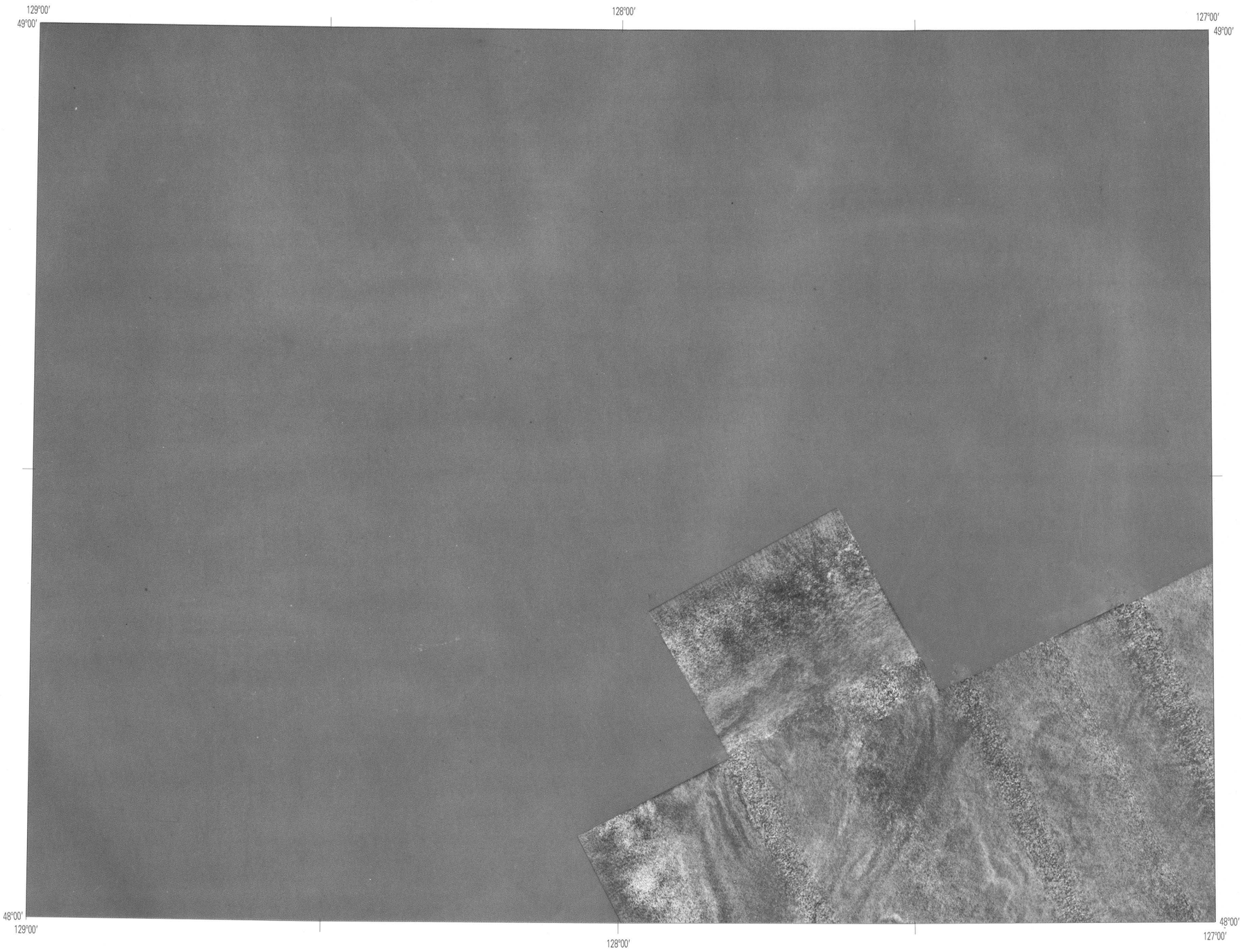
SHEET LOCATION

BATHYMETRIC CONTOUR INTERVAL 100 METERS

DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

SONAR MOSAIC
SHEET 36

ATLAS OF THE EXCLUSIVE ECONOMIC ZONE
WESTERN CONTERMINOUS UNITED STATES
I–1792



NO DATA

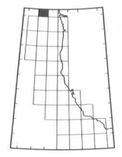
SCALE 1:500,000

10 0 10 20 30 NAUTICAL MILES

10 0 10 20 30 40 50 KILOMETERS

TRANSVERSE MERCATOR PROJECTION

1 centimeter equals 5 kilometers

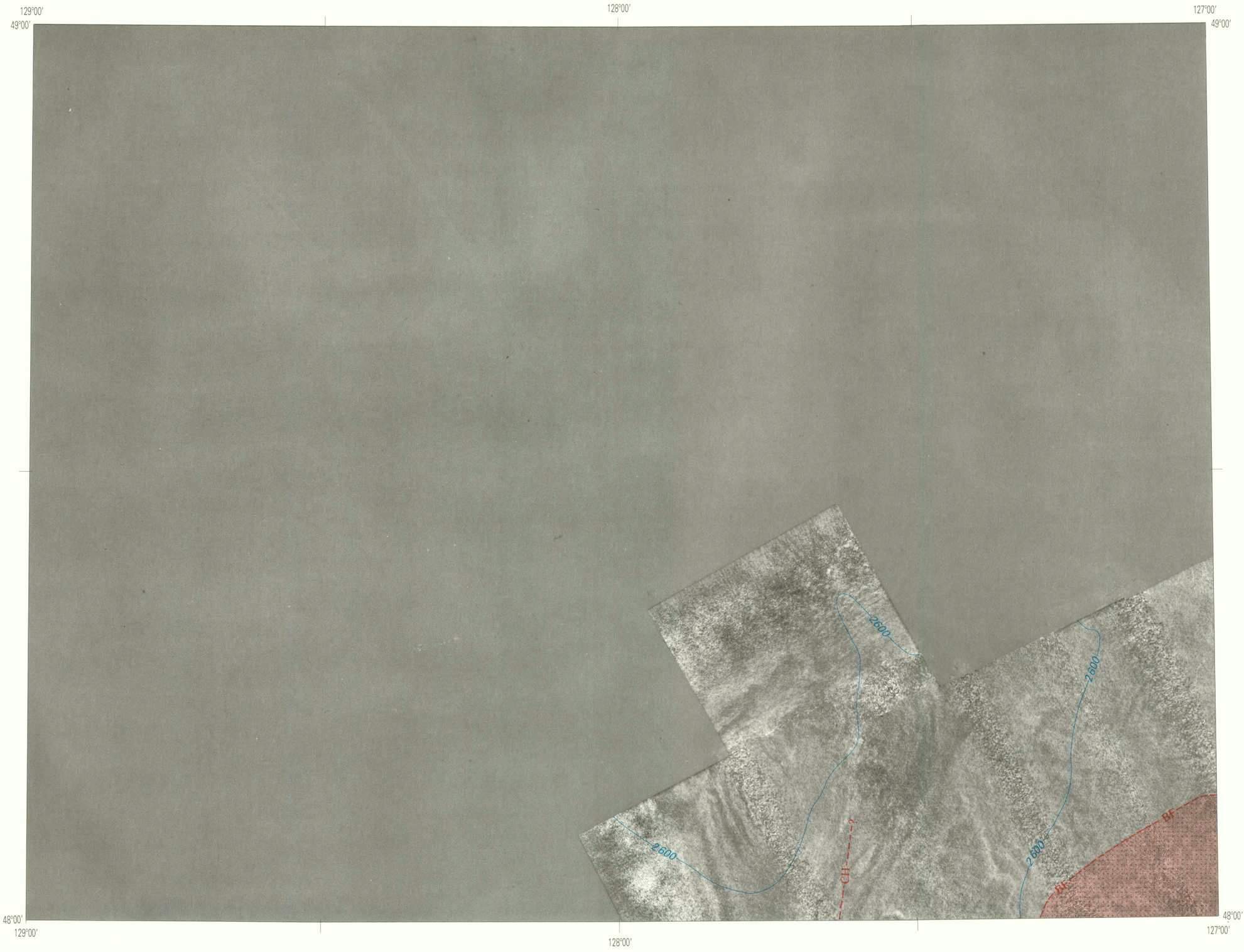


SHEET LOCATION

DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

GEOLOGIC INTERPRETATION
SHEET 36
BATHYMETRY

ATLAS OF THE EXCLUSIVE ECONOMIC ZONE
WESTERN CONTERMINOUS UNITED STATES
I–1792



Base from Chase and others (1981)

NO DATA

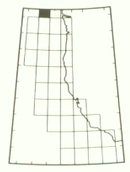
SCALE 1:500,000

10 0 10 20 30 NAUTICAL MILES

10 0 10 20 30 40 50 KILOMETERS

TRANSVERSE MERCATOR PROJECTION

1 centimeter equals 5 kilometers

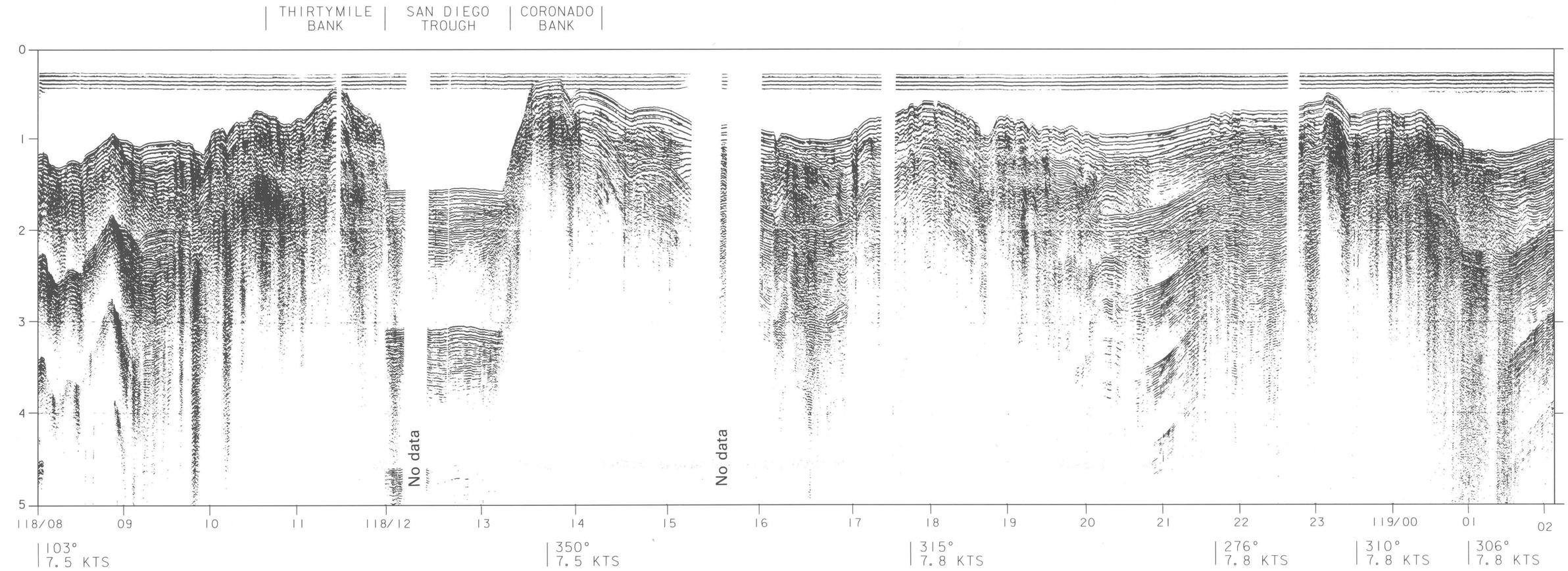


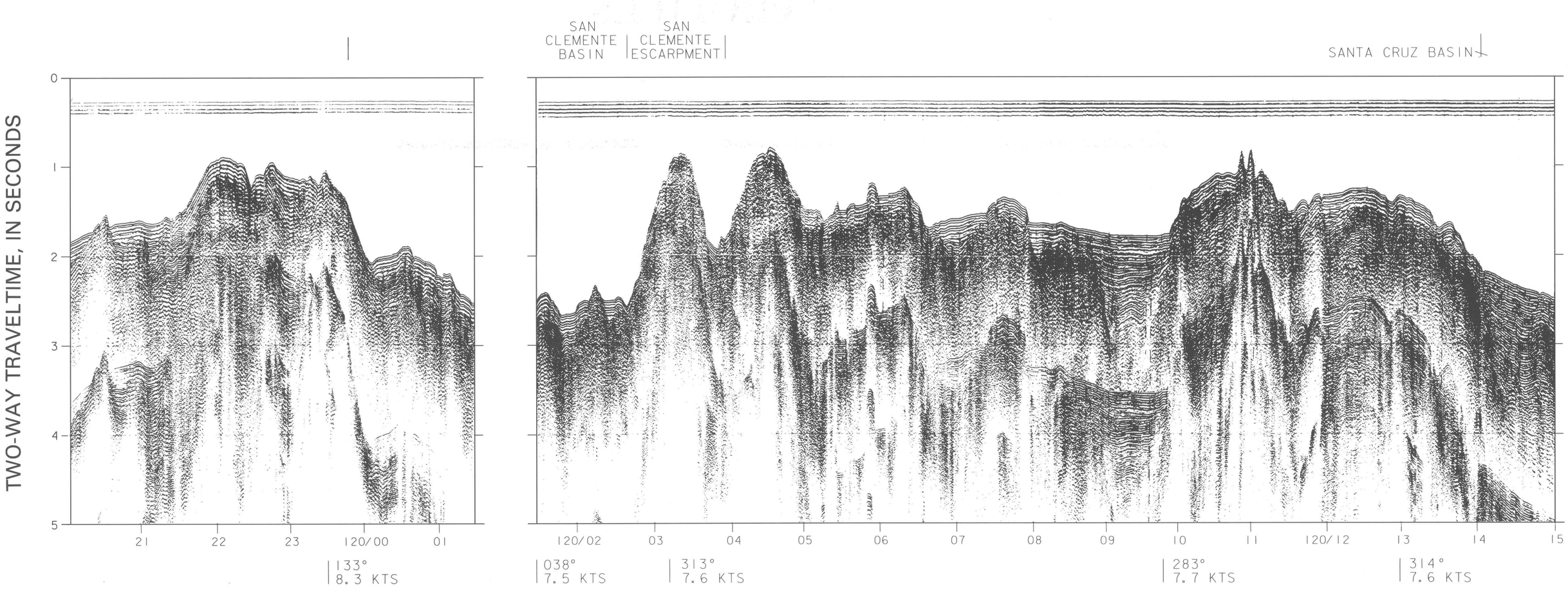
SHEET LOCATION

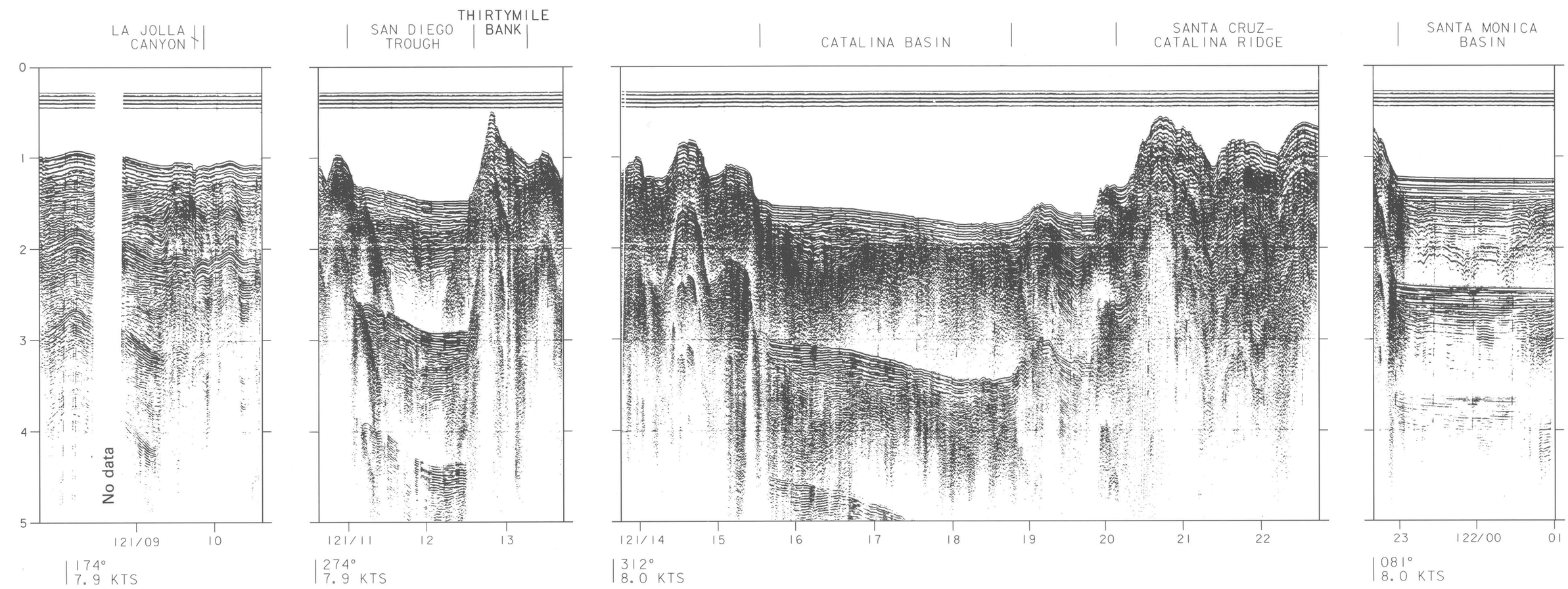
BATHYMETRIC CONTOUR INTERVAL 100 METERS

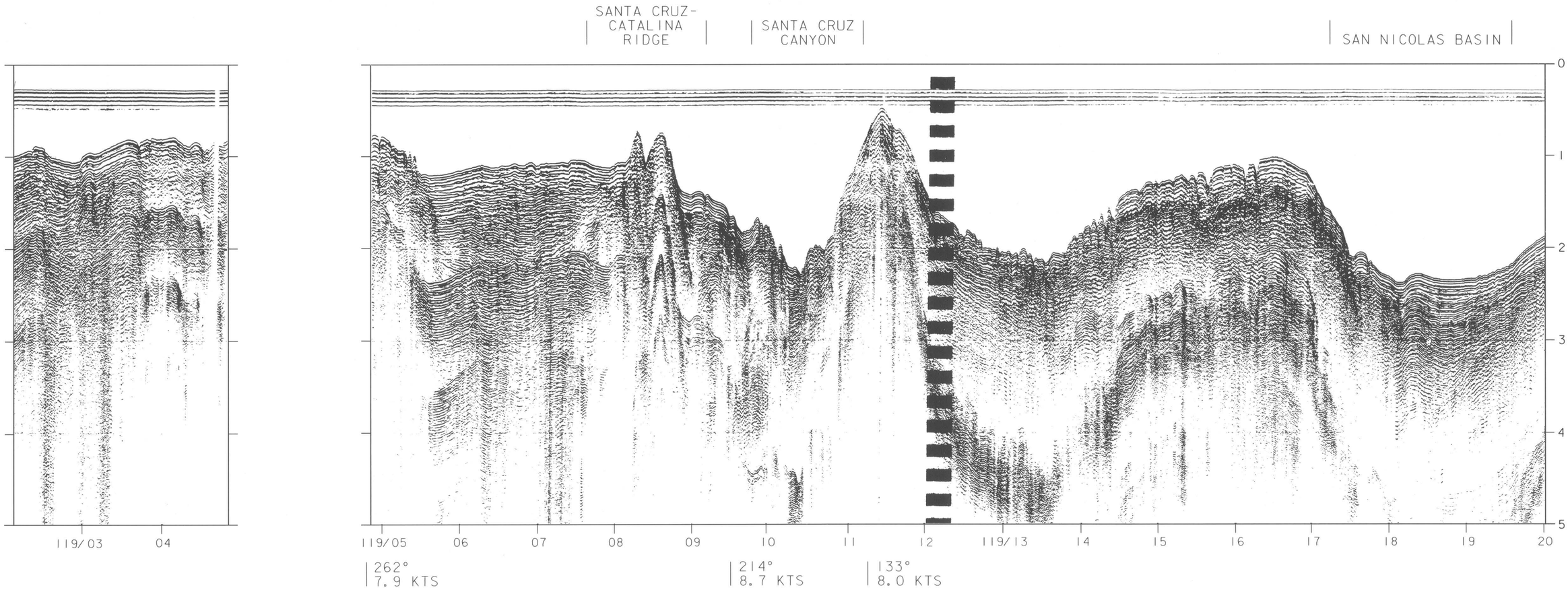
SEISMIC PROFILES

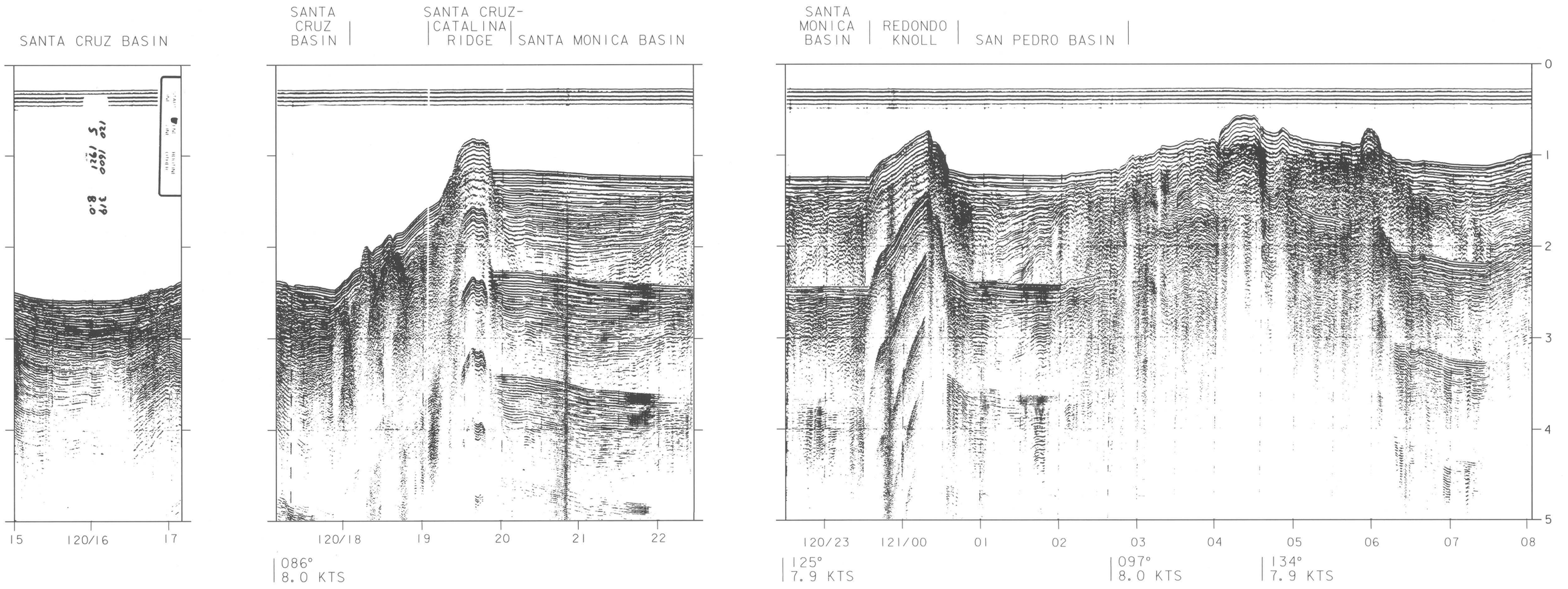
SEISMIC PROFILES

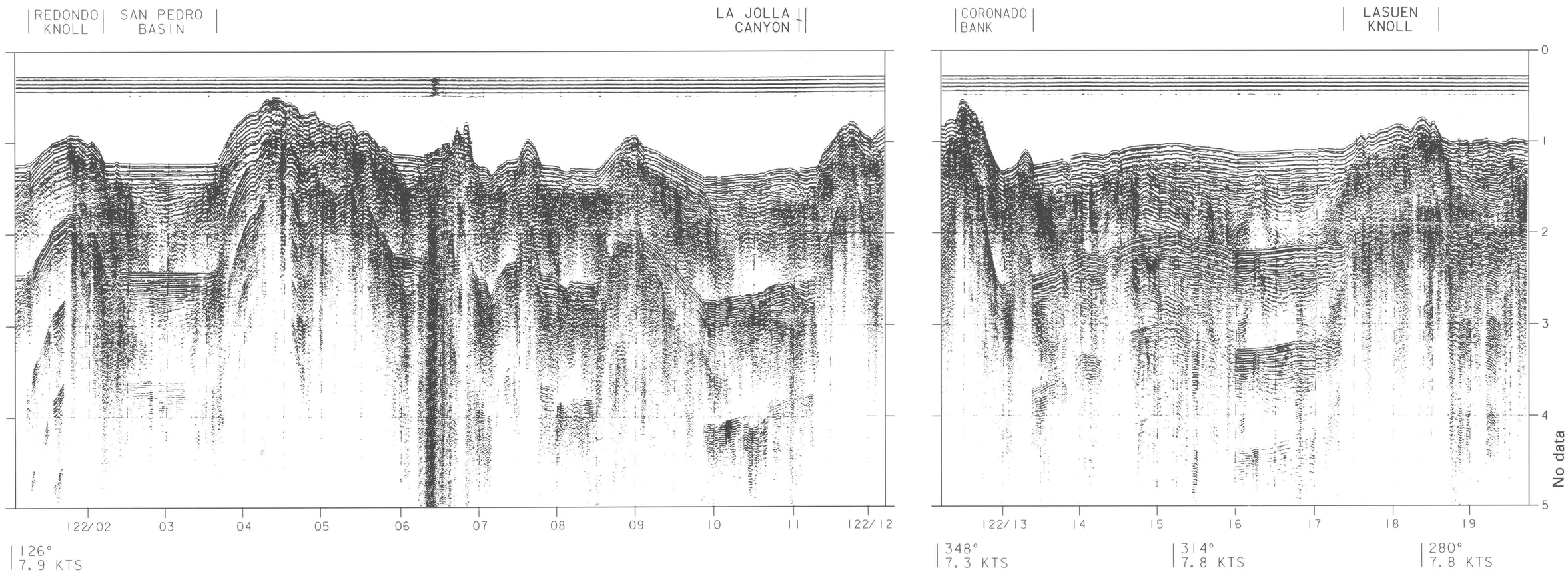

THIRTYMILE BANK
SAN DIEGO TROUGH
CORONADO BANK
No data
No data
0
1
2
3
4
5
118/08
09
10
11
118/12
13
14
15
16
17
18
19
20
21
22
23
119/00
01
02
103°
7.5 KTS
350°
7.5 KTS
315°
7.8 KTS
276°
7.8 KTS
310°
7.8 KTS
306°
7.8 KTS


SAN CLEMENTE BASIN
SAN CLEMENTE ESCARPMENT
SANTA CRUZ BASIN
TWO-WAY TRAVELTIME, IN SECONDS
0
1
2
3
4
5
21
22
23
120/00
01
120/02
03
04
05
06
07
08
09
10
11
120/12
13
14
15
133°
8.3 KTS
038°
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313°
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7.7 KTS
314°
7.6 KTS

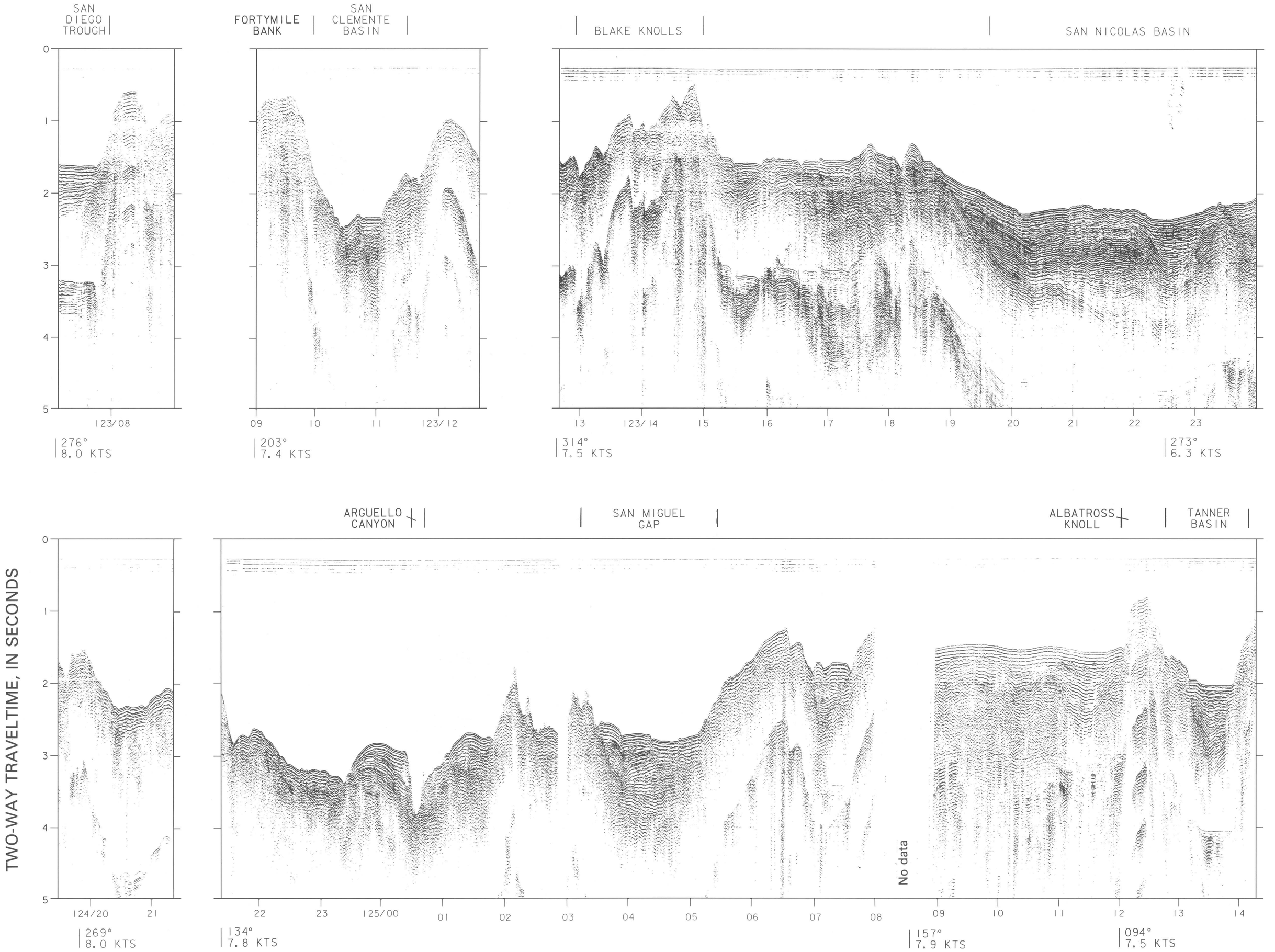

LA JOLLA CANYON
SAN DIEGO TROUGH
THIRTYMILE BANK
CATALINA BASIN
SANTA CRUZ–CATALINA RIDGE
SANTA MONICA BASIN
No data
0
1
2
3
4
5
121/09
10
121/11
12
13
121/14
15
16
17
18
19
20
21
22
23
122/00
01
174°
7.9 KTS
274°
7.9 KTS
312°
8.0 KTS
081°
8.0 KTS
HOURS

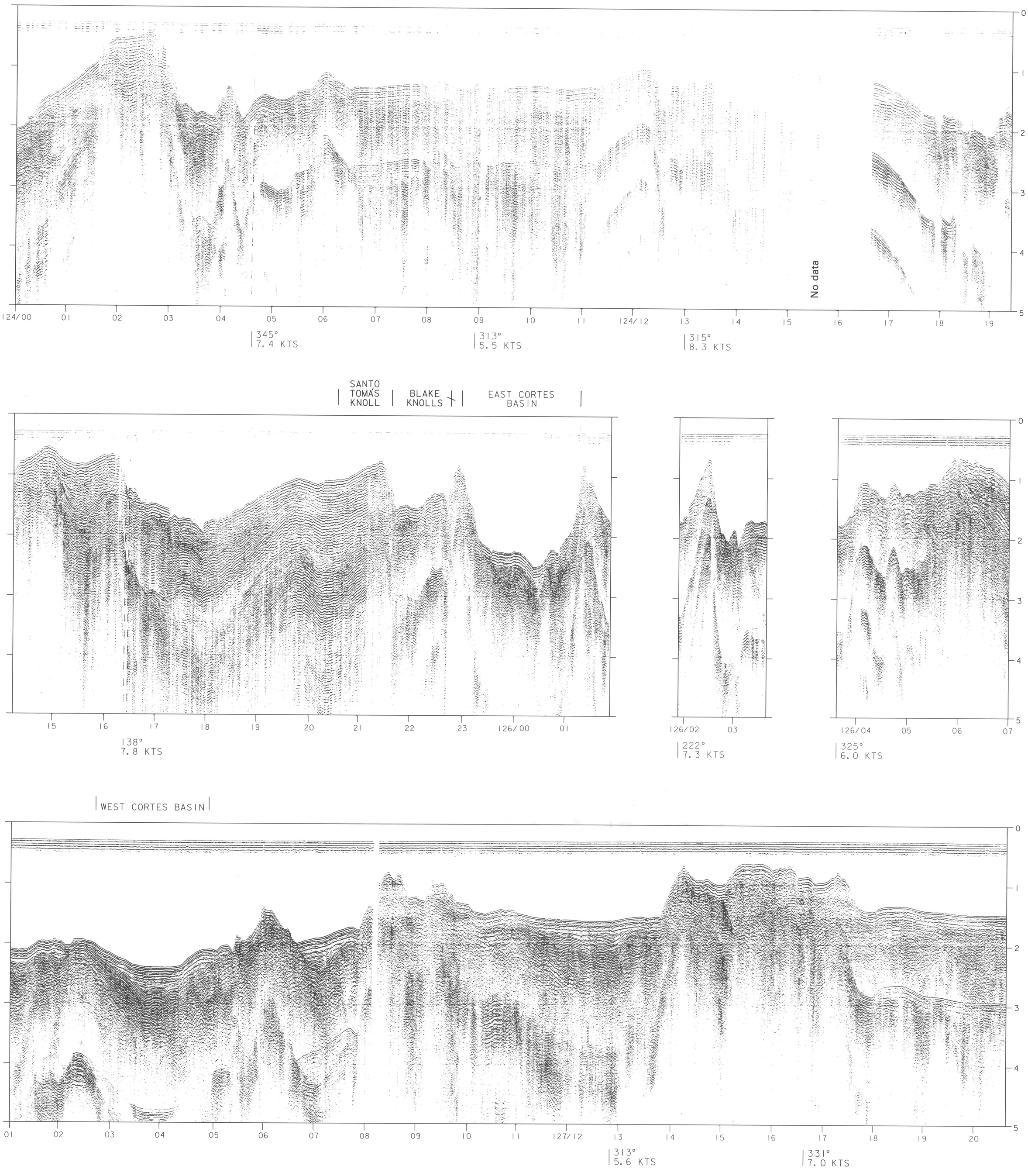

SANTA CRUZ-
CATALINA
RIDGE
SANTA CRUZ
CANYON
SAN NICOLAS BASIN
0
1
2
3
4
5
119/03
04
119/05
06
07
08
09
10
11
12
119/13
14
15
16
17
18
19
20
262°
7.9 KTS
214°
8.7 KTS
133°
8.0 KTS


SANTA CRUZ BASIN
SANTA
CRUZ
BASIN
SANTA CRUZ-
CATALINA
RIDGE
SANTA MONICA BASIN
SANTA
MONICA
BASIN
REDONDO
KNOLL
SAN PEDRO BASIN
TWO-WAY TRAVELTIME, IN SECONDS
0
1
2
3
4
5
15
120/16
17
120/18
19
20
21
22
120/23
121/00
01
02
03
04
05
06
07
08
086°
8.0 KTS
125°
7.9 KTS
097°
8.0 KTS
134°
7.9 KTS


REDONDO
KNOLL
SAN PEDRO
BASIN
LA JOLLA
CANYON
CORONADO
BANK
LASUEN
KNOLL
0
1
2
3
4
5
No data
122/02
03
04
05
06
07
08
09
10
11
122/12
122/13
14
15
16
17
18
19
126°
7.9 KTS
348°
7.3 KTS
314°
7.8 KTS
280°
7.8 KTS

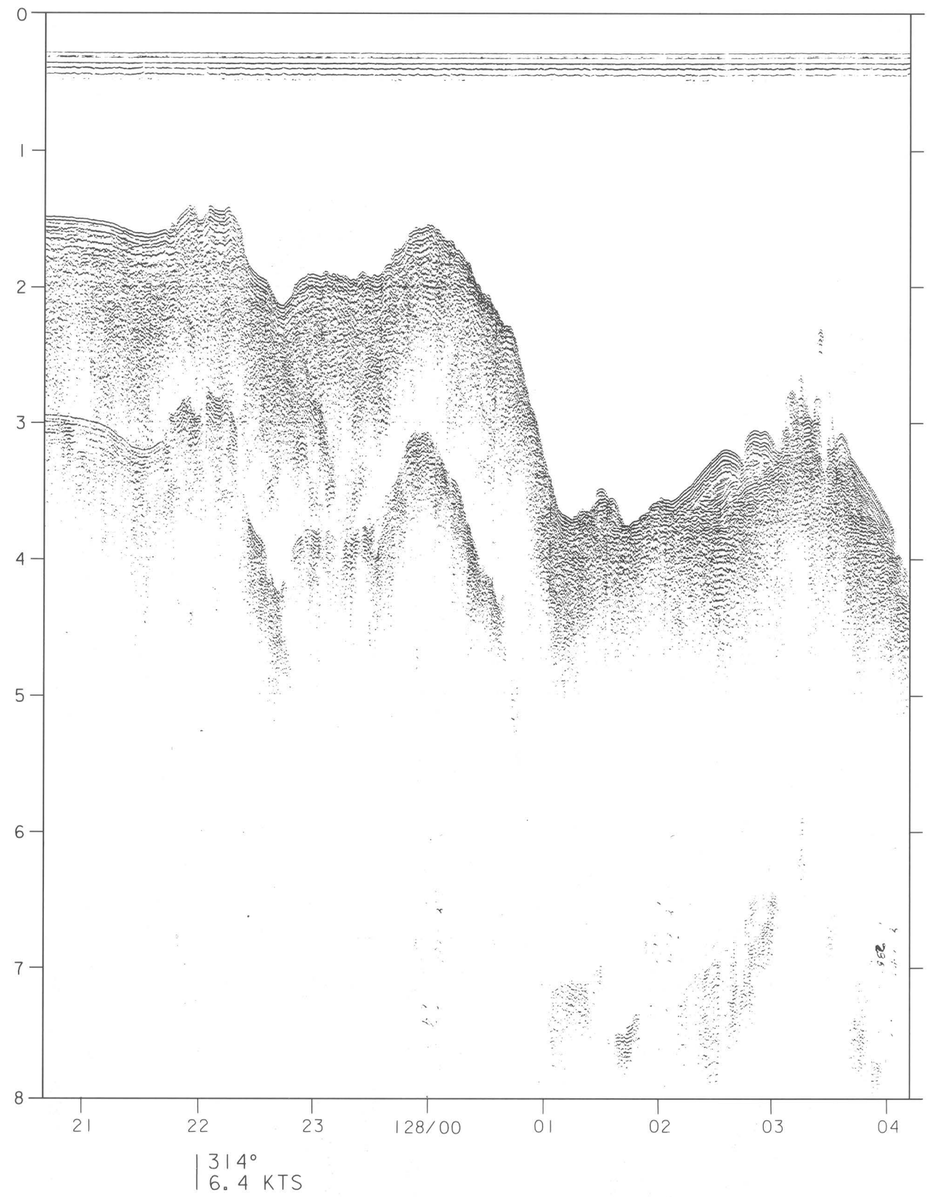
HOURS

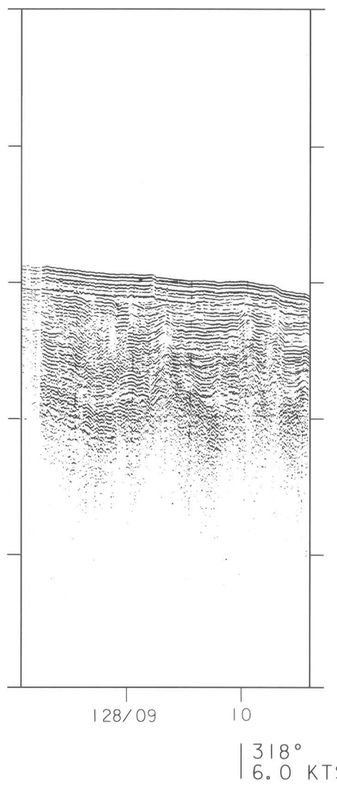

SAN DIEGO TROUGH
FORTYMILE BANK
SAN CLEMENTE BASIN
BLAKE KNOLLS
SAN NICOLAS BASIN
ARGUELLO CANYON
SAN MIGUEL GAP
ALBATROSS KNOLL
TANNER BASIN
EAST CORTES BASIN
TWO-WAY TRAVELTIME, IN SECONDS
0
1
2
3
4
5
123/08
276°
8.0 KTS
09
10
11
123/12
203°
7.4 KTS
13
123/14
15
16
17
18
19
20
21
22
23
314°
7.5 KTS
273°
6.3 KTS
124/20
21
269°
8.0 KTS
22
23
125/00
01
02
03
04
05
06
07
08
134°
7.8 KTS
No data
09
10
11
12
13
14
157°
7.9 KTS
094°
7.5 KTS
126/08
09
10
11
105°
7.8 KTS
126/12
13
14
15
16
17
18
206°
7.6 KTS
126/19
20
21
22
23
127/00
01
320°
4.9 KTS
HOURS

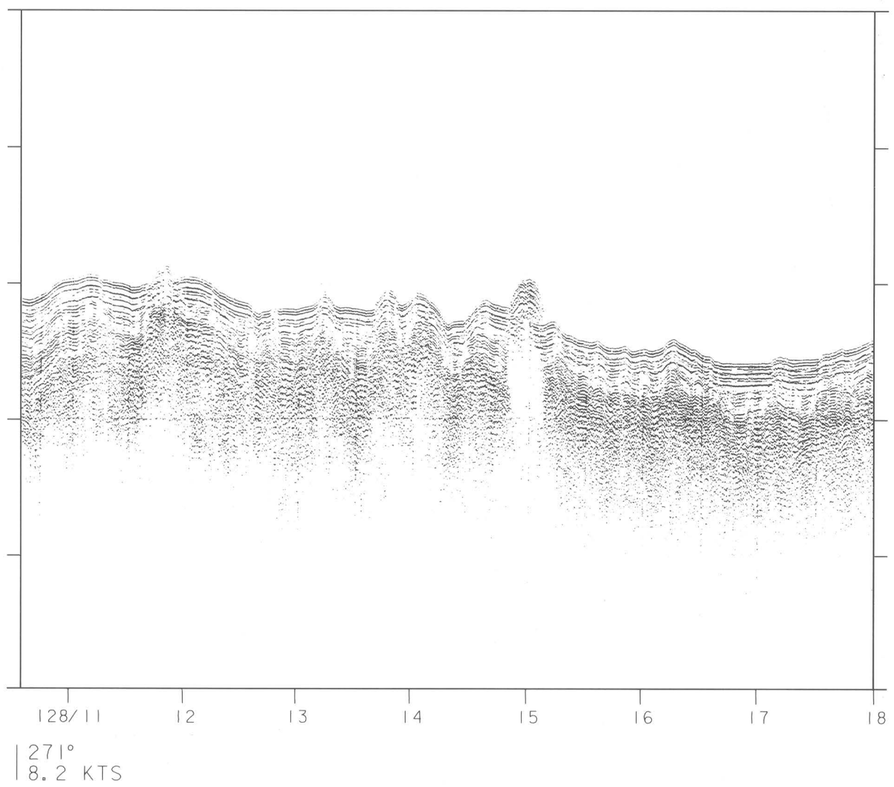

SANTA ROSA-
CORTES RIDGE
No data
124/00
01
02
03
04
05
06
07
08
09
10
11
124/12
13
14
15
16
17
18
19
345°
7.4 KTS
313°
5.5 KTS
315°
8.3 KTS
SANTO
TOMÁS
KNOLL
BLAKE
KNOLLS
EAST CORTES
BASIN
15
16
17
18
19
20
21
22
23
126/00
01
138°
7.8 KTS
126/02
03
222°
7.3 KTS
126/04
05
06
07
325°
6.0 KTS
WEST CORTES BASIN
01
02
03
04
05
06
07
08
09
10
11
127/12
13
14
15
16
17
18
19
20
313°
5.6 KTS
331°
7.0 KTS
0
1
2
3
4
5
TWO-WAY TRAVELTIME, IN SECONDS
HOURS

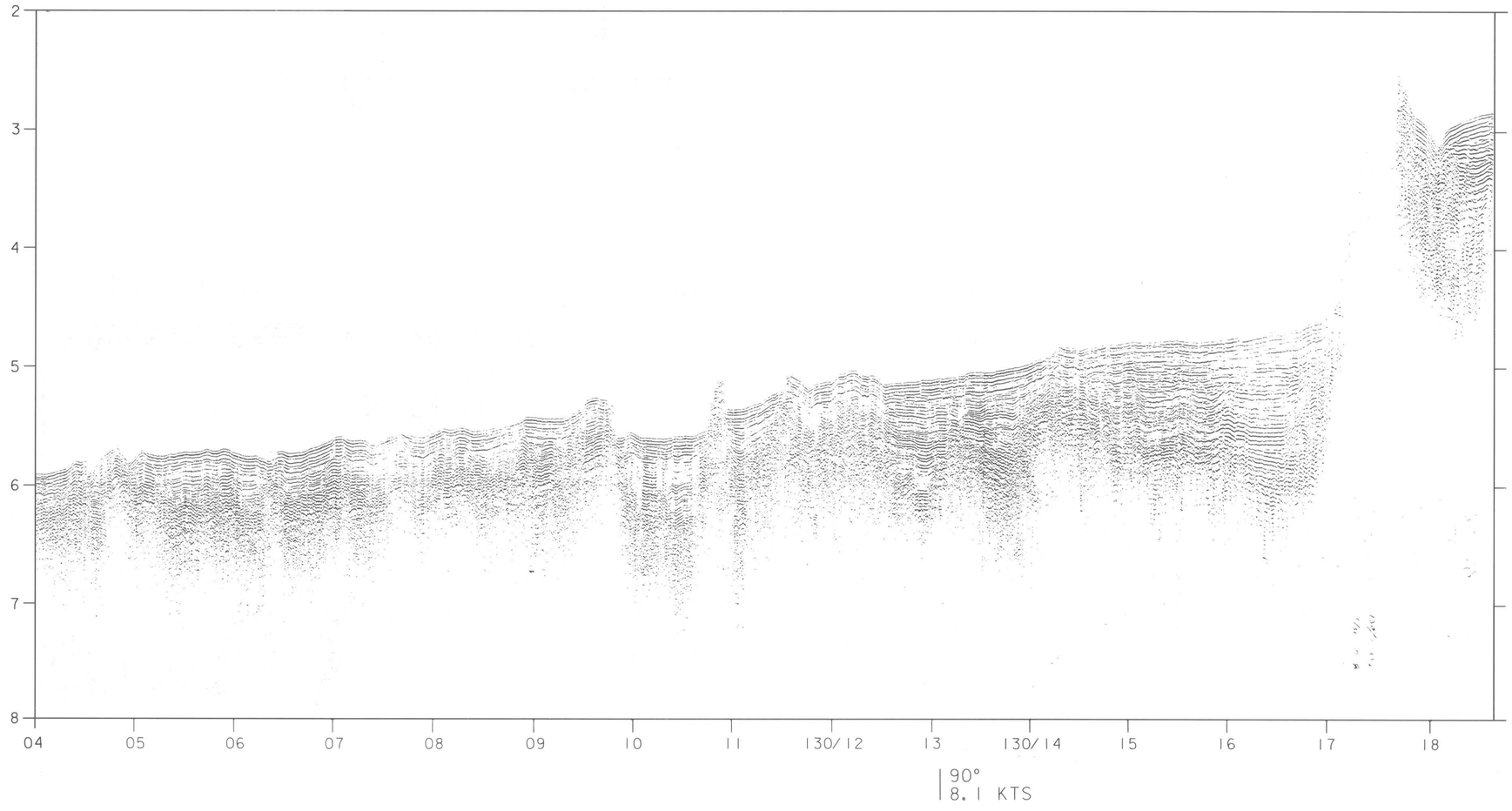
SAN MIGUEL GAP

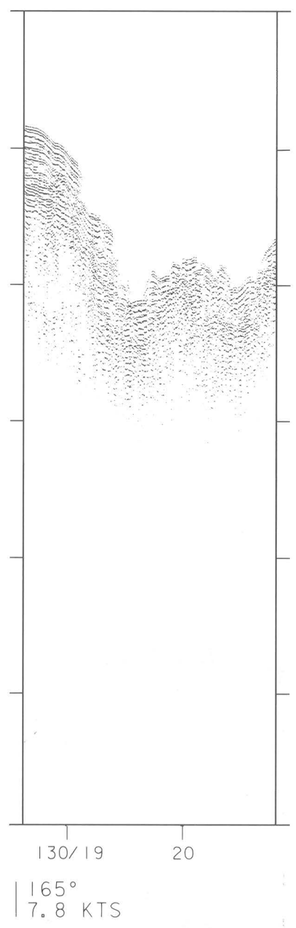
TWO-WAY TRAVELTIME, IN SECONDS



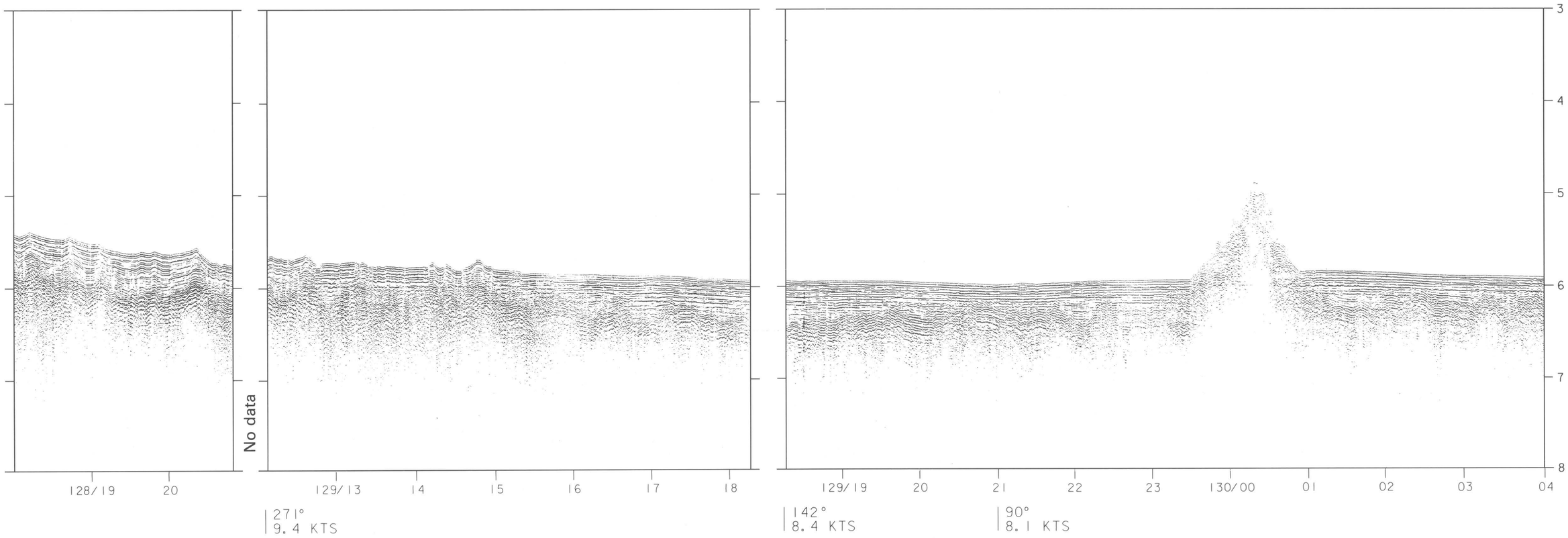


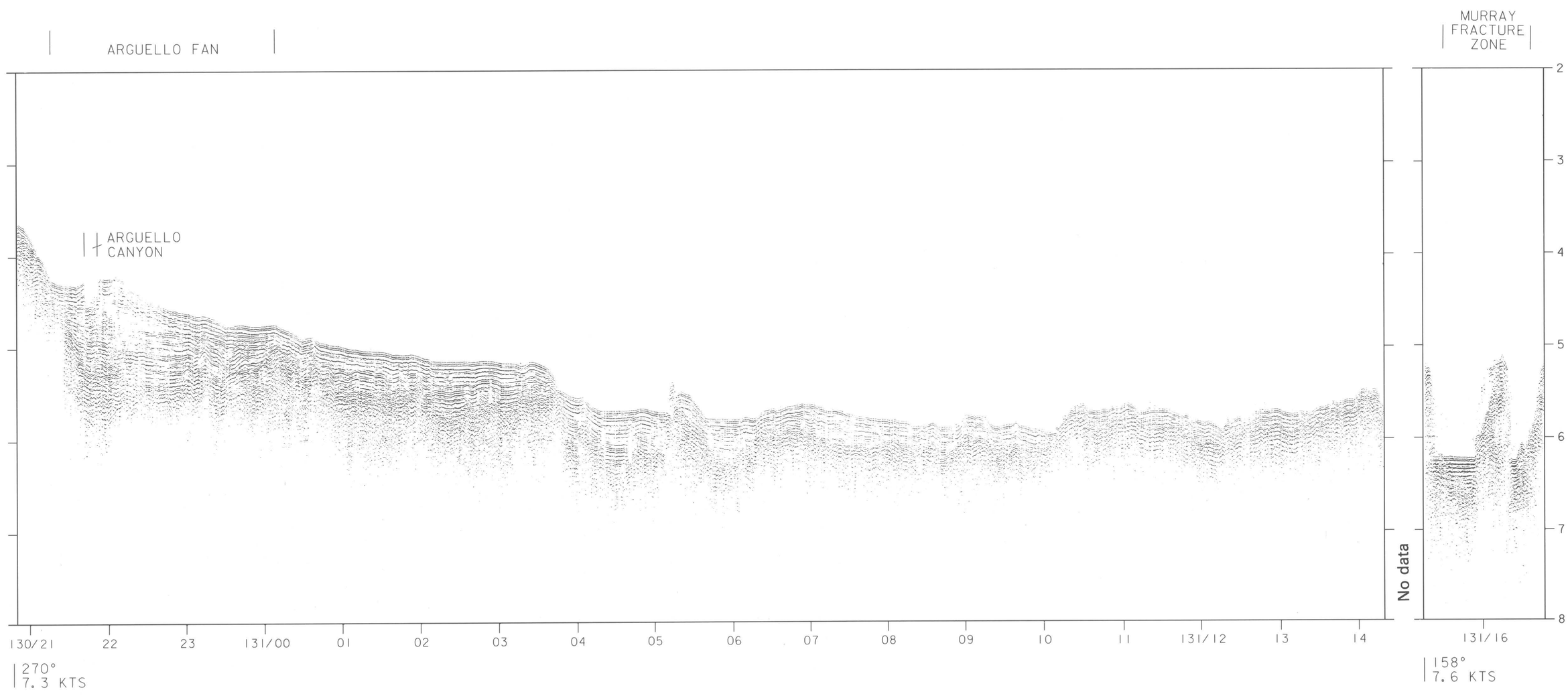




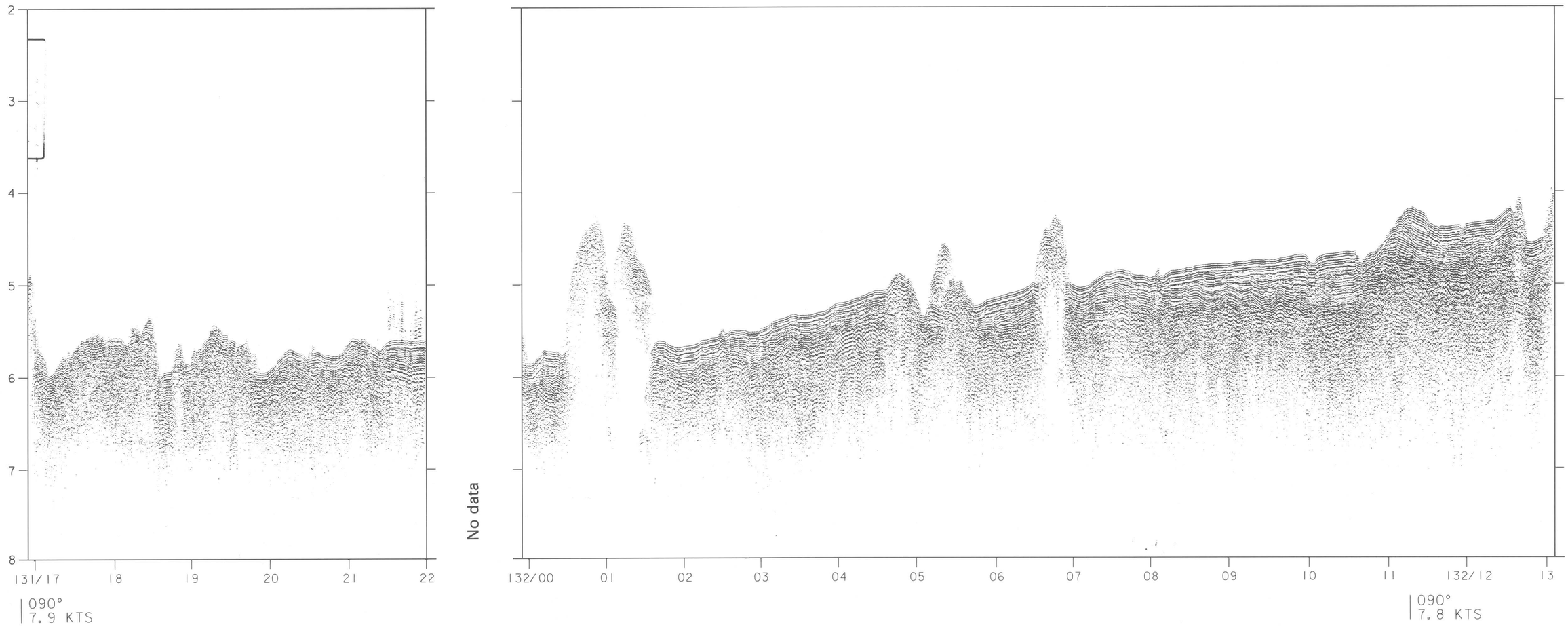


HOURS

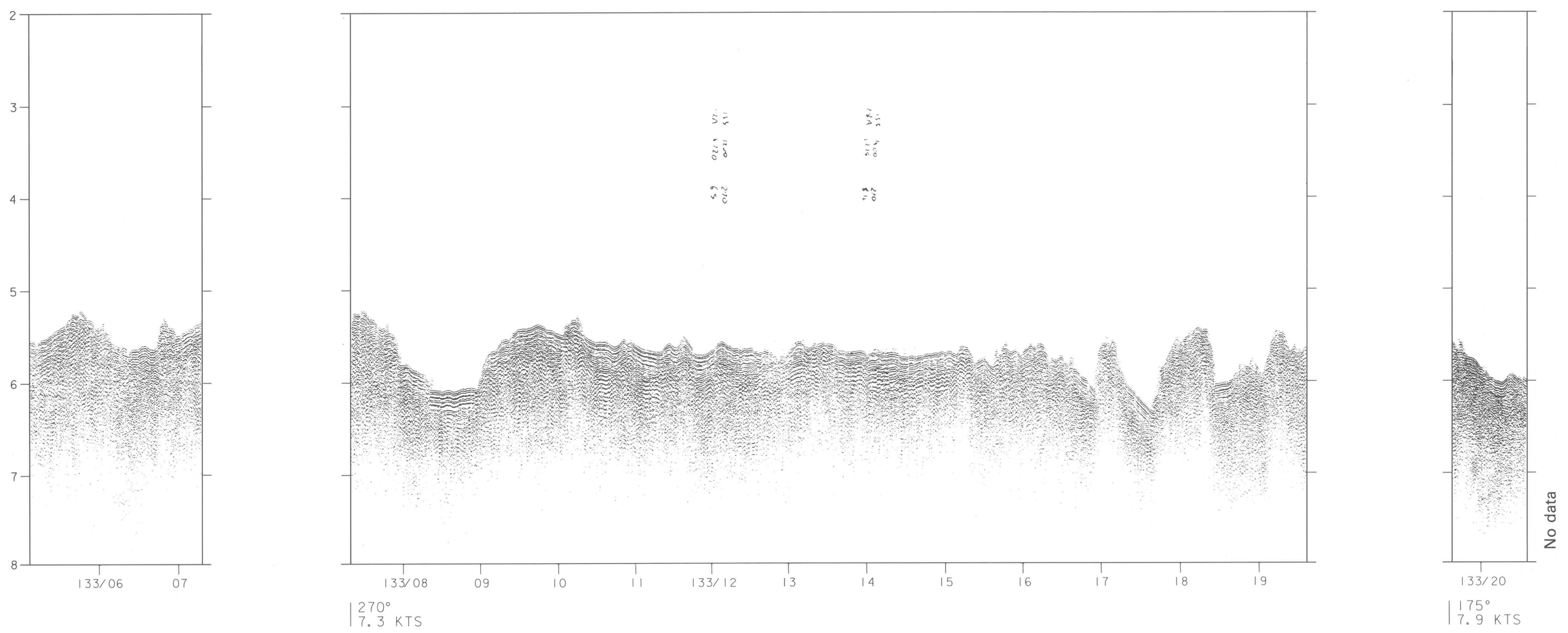

No data
128/19
20
129/13
14
15
16
17
18
271°
9.4 KTS
129/19
20
21
22
23
130/00
01
02
03
04
142°
8.4 KTS
90°
8.1 KTS
3
4
5
6
7
8
TWO-WAY TRAVELTIME, IN SECONDS


ARGUELLO FAN
ARGUELLO CANYON
MURRAY FRACTURE ZONE
No data
130/21
22
23
131/00
01
02
03
04
05
06
07
08
09
10
11
131/12
13
14
131/16
270°
7.3 KTS
158°
7.6 KTS
2
3
4
5
6
7
8

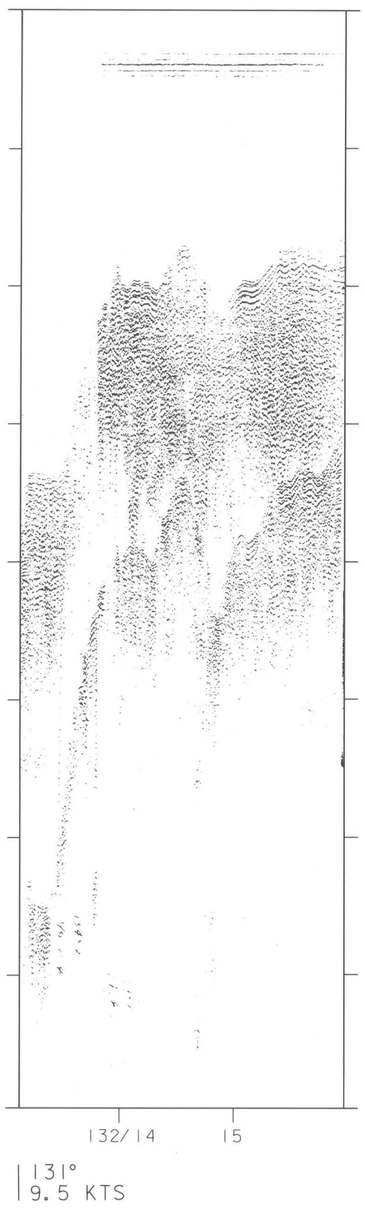
HOURS

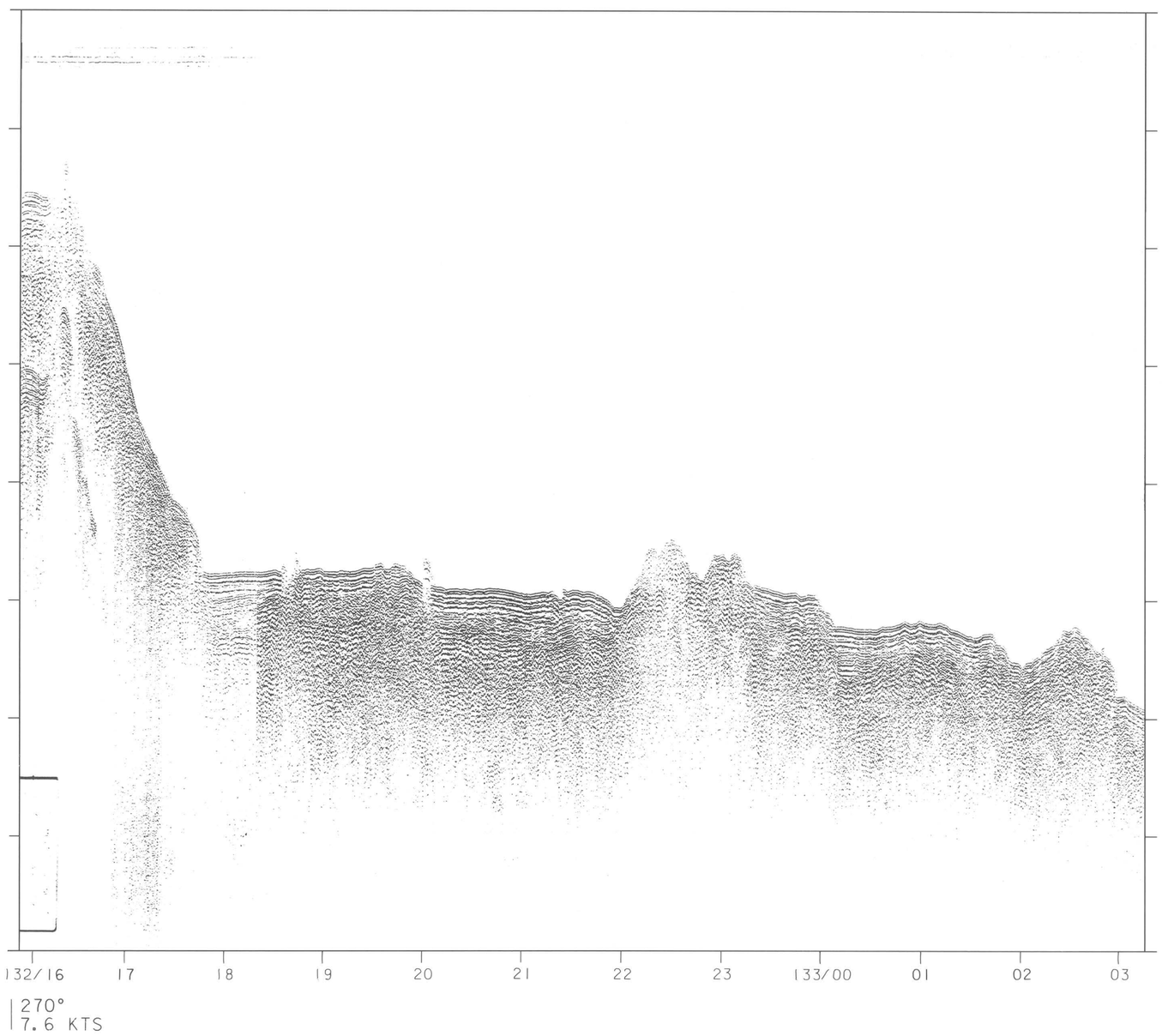


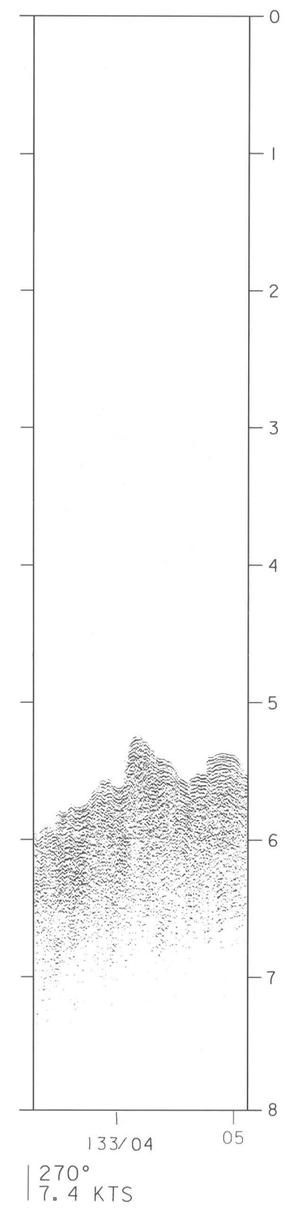
TWO-WAY TRAVELTIME, IN SECONDS

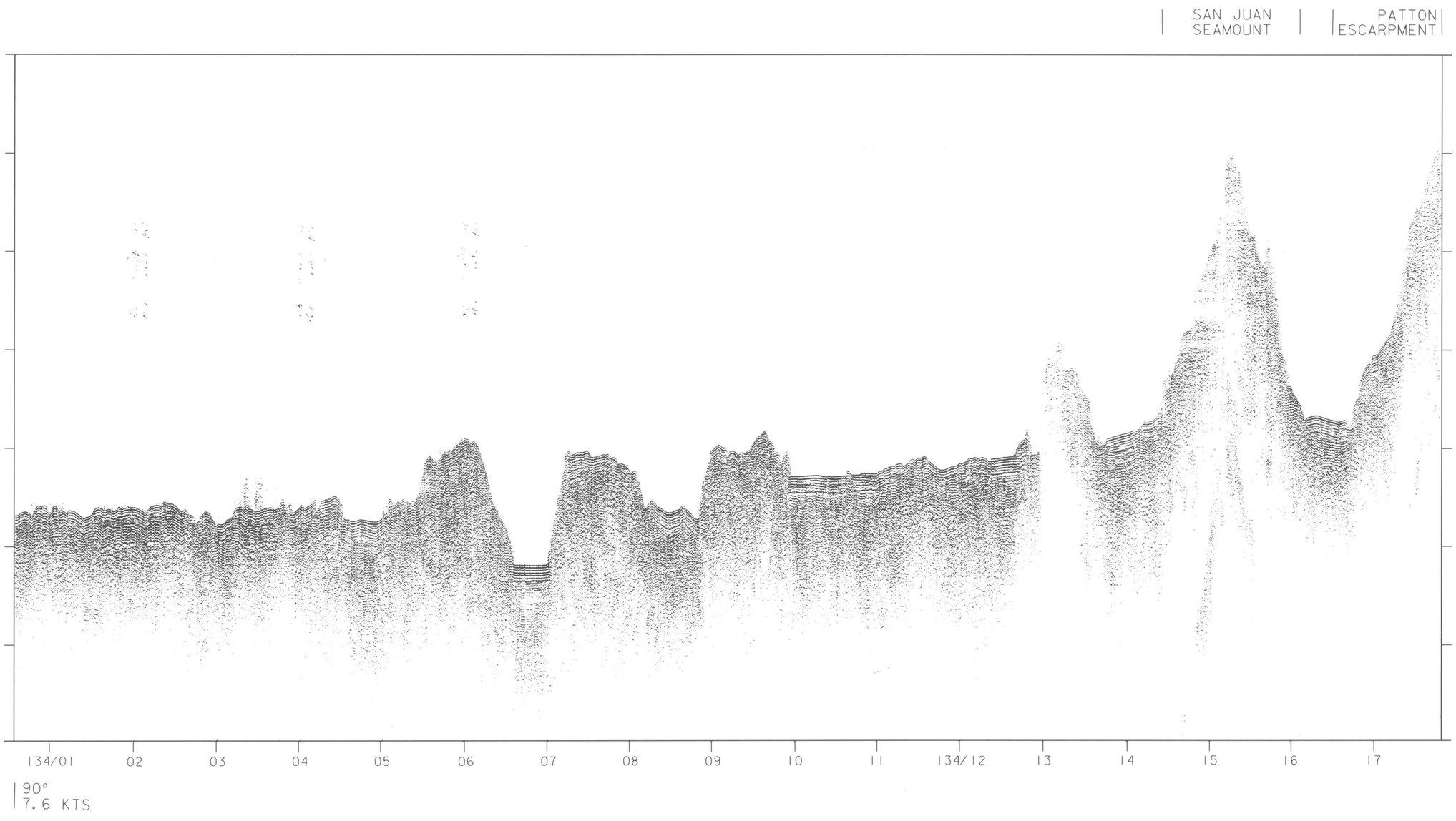


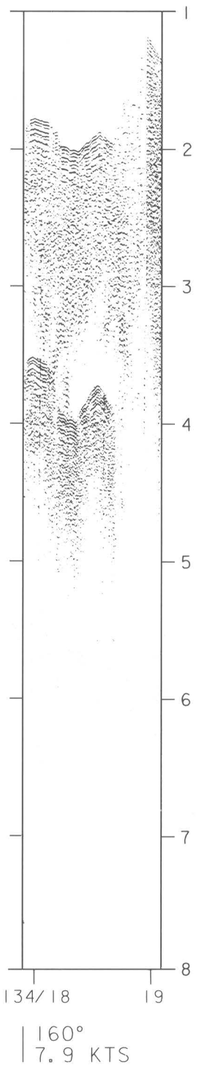
HOURS





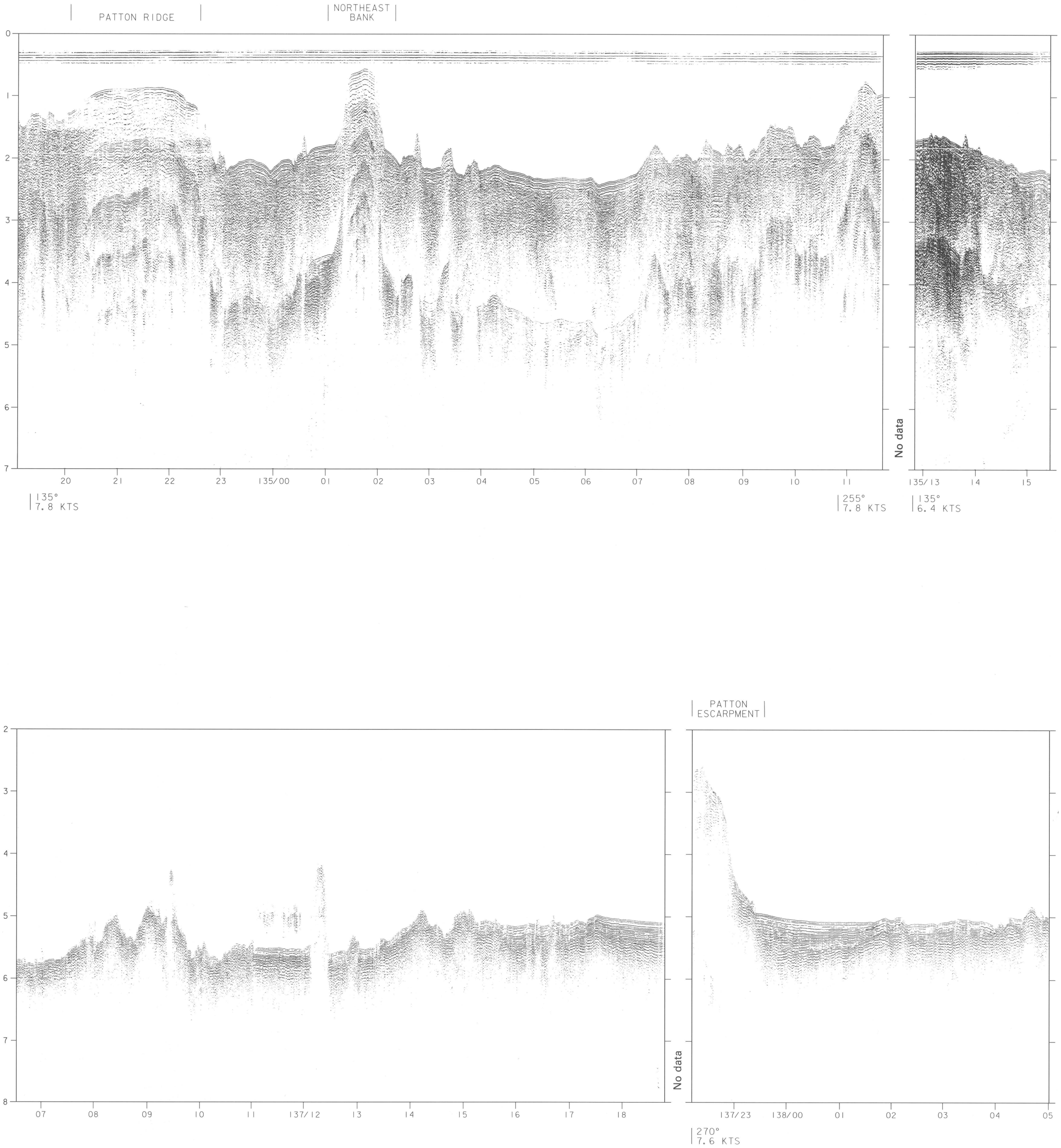


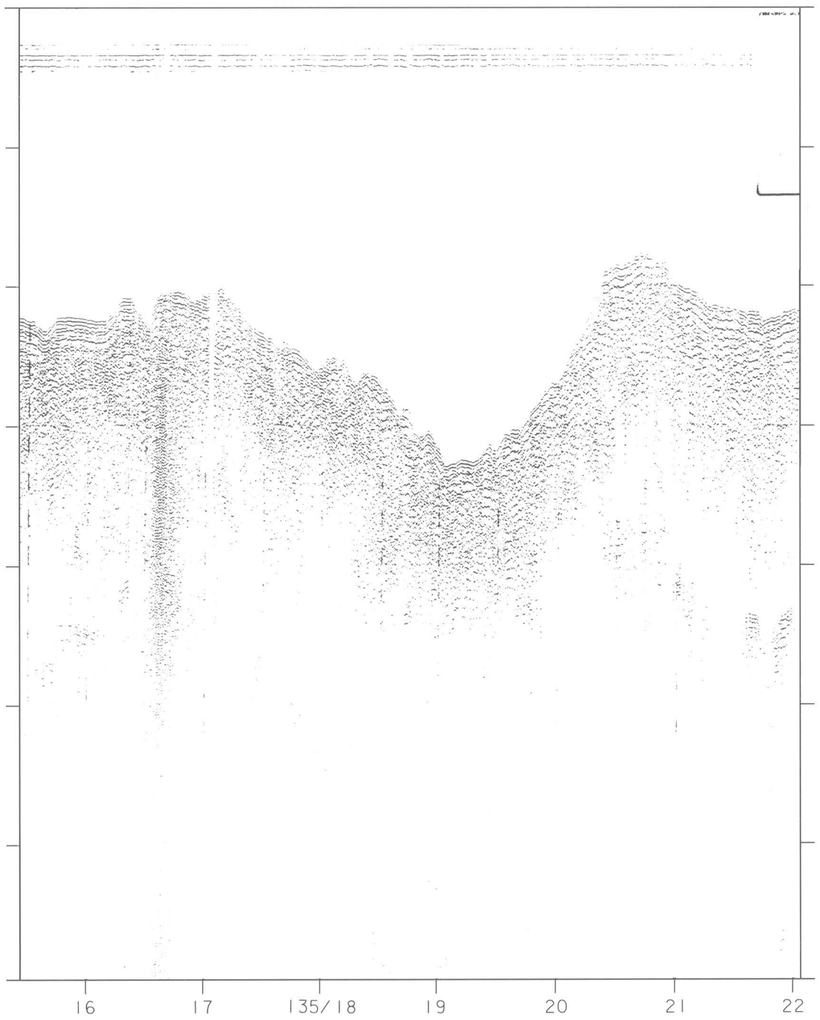


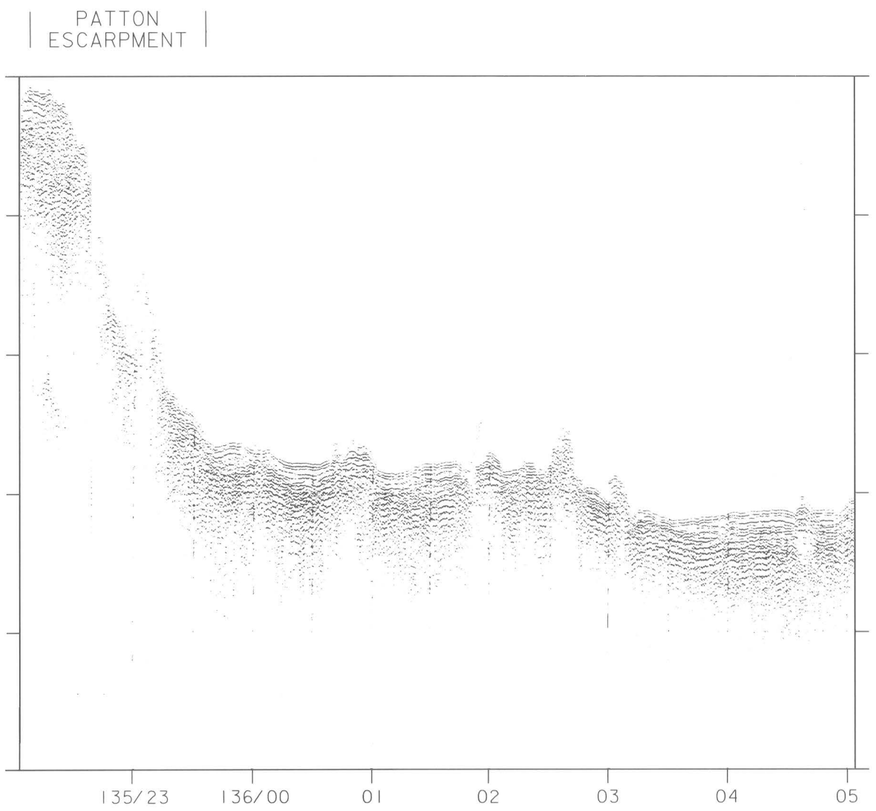


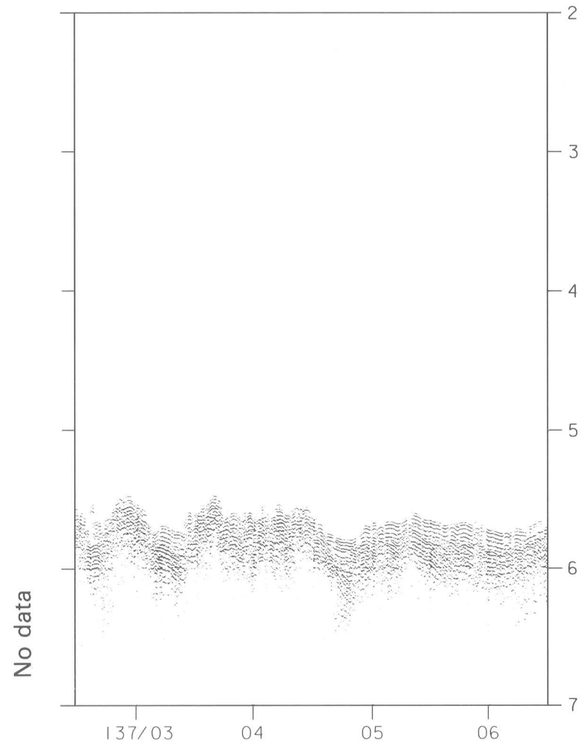
TWO-WAY TRAVELTIME, IN SECONDS

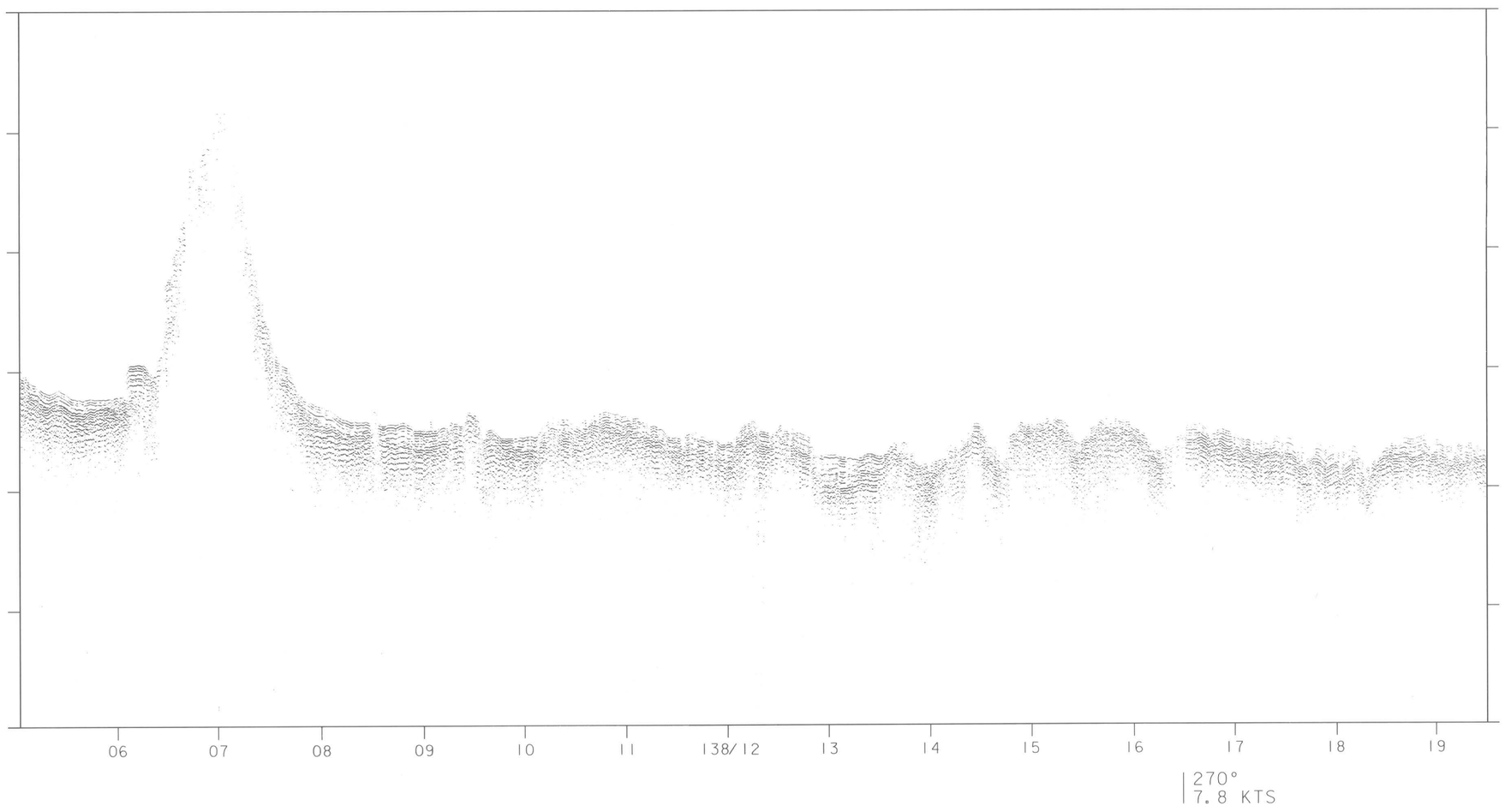
HOURS

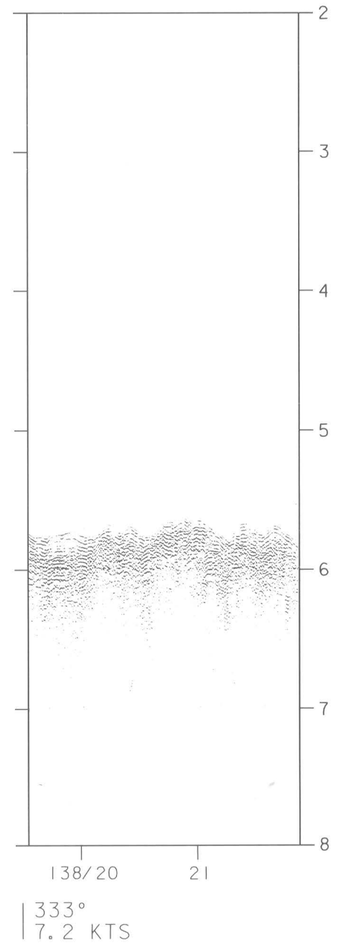

PATTON RIDGE
NORTHEAST BANK
PATTON ESCARPMENT
TWO-WAY TRAVELTIME, IN SECONDS
0
1
2
3
4
5
6
7
8
No data
20
21
22
23
135/00
01
02
03
04
05
06
07
08
09
10
11
135/13
14
15
135°
7.8 KTS
255°
7.8 KTS
135°
6.4 KTS
07
08
09
10
11
137/12
13
14
15
16
17
18
137/23
138/00
01
02
03
04
05
270°
7.6 KTS
HOURS





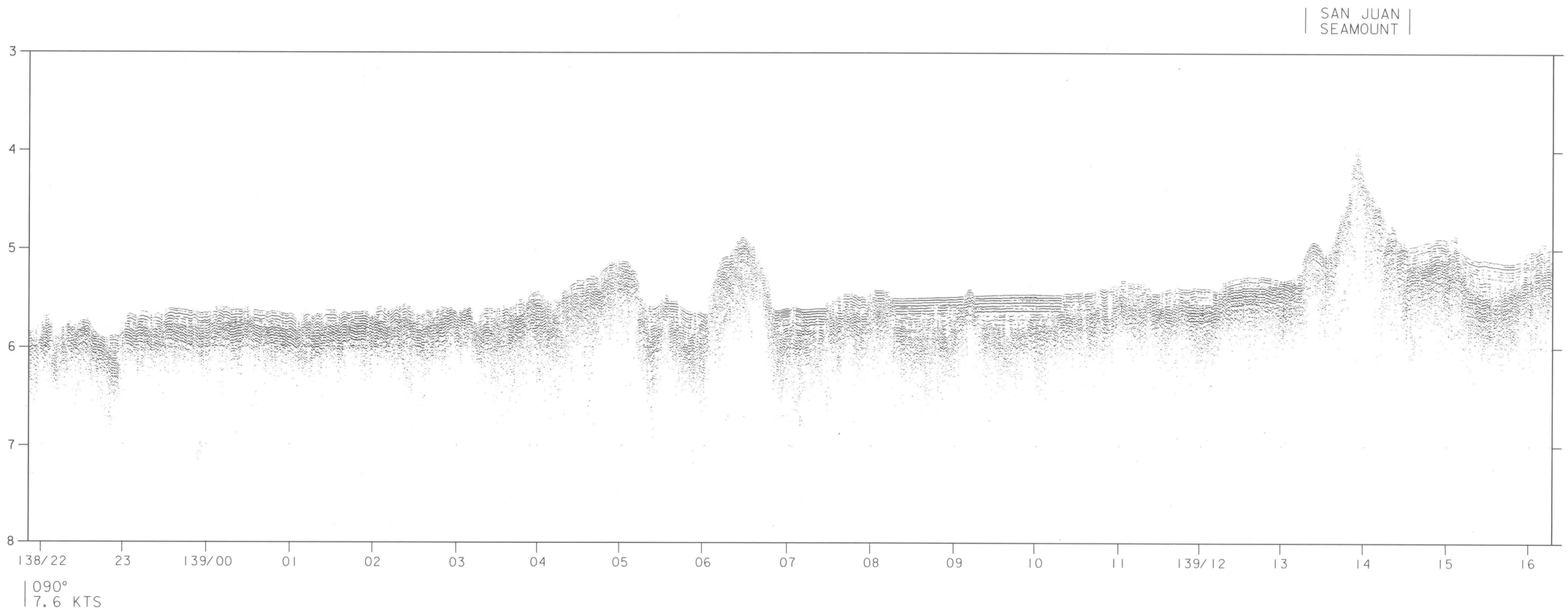




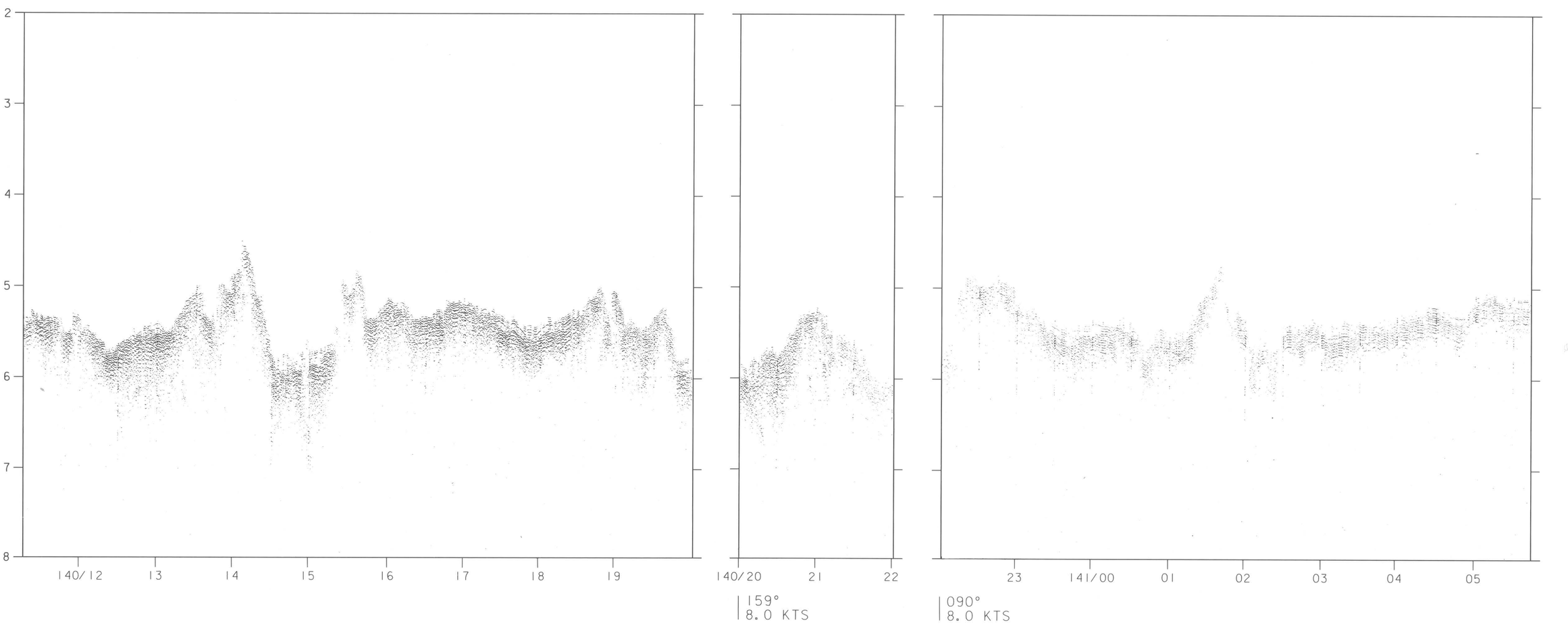


TWO-WAY TRAVELTIME, IN SECONDS

HOURS

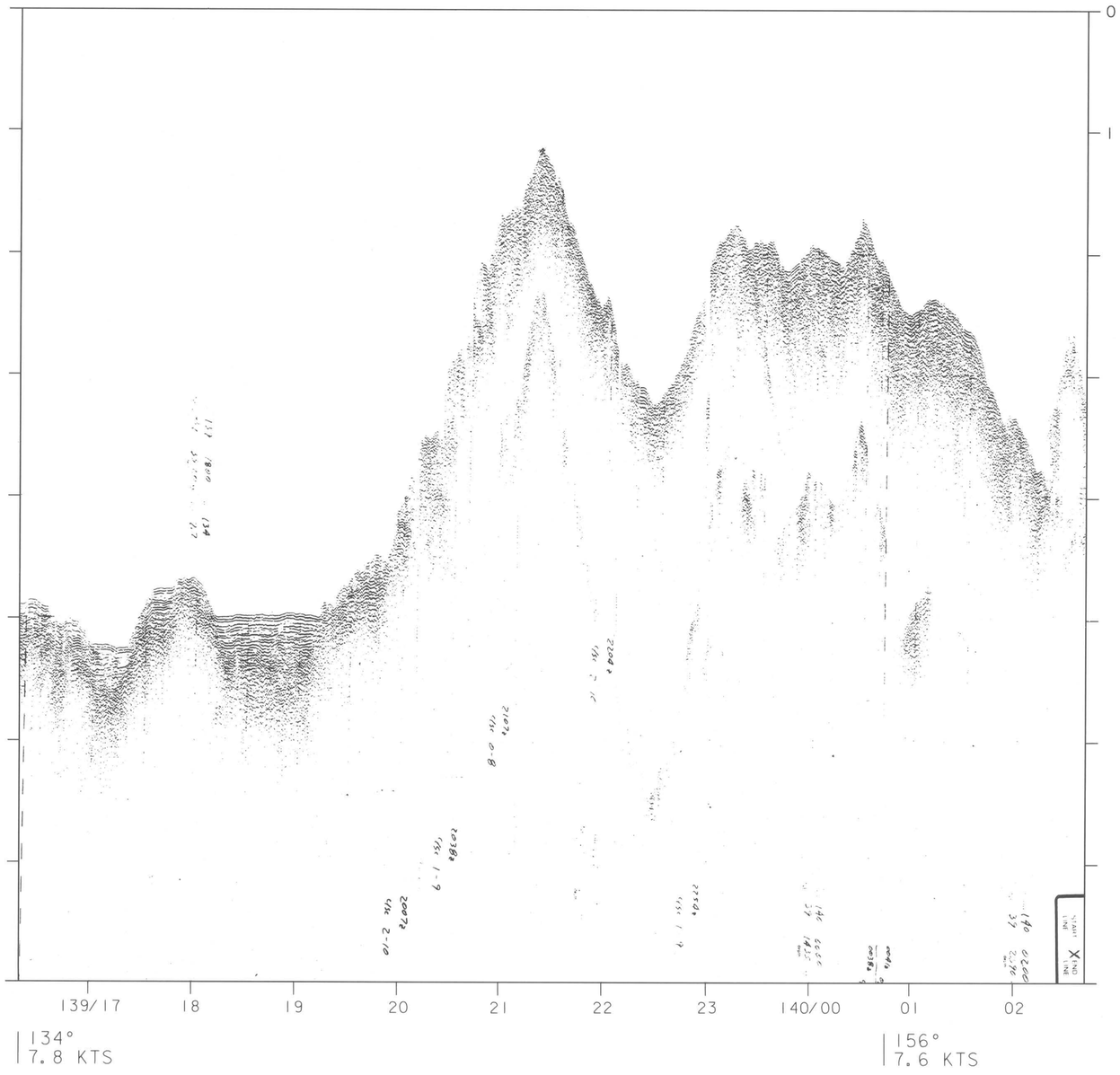


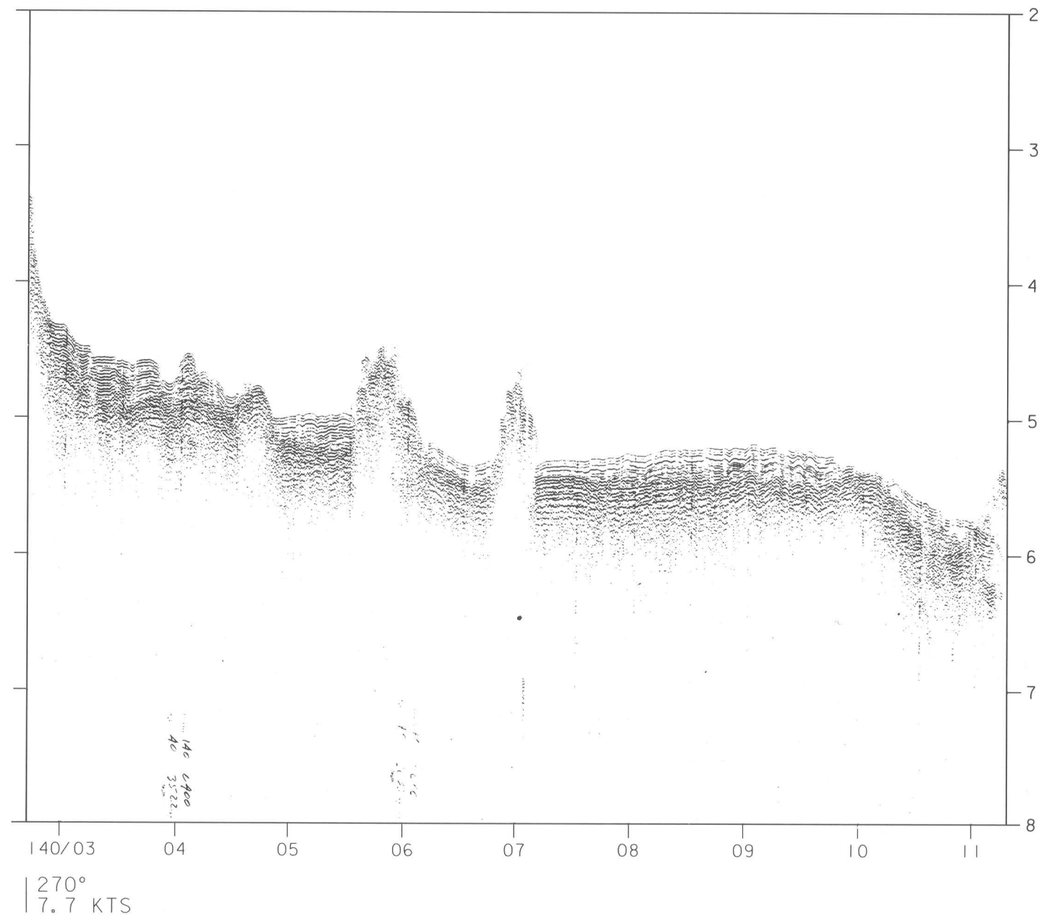
TWO-WAY TRAVELTIME, IN SECONDS



HOURS

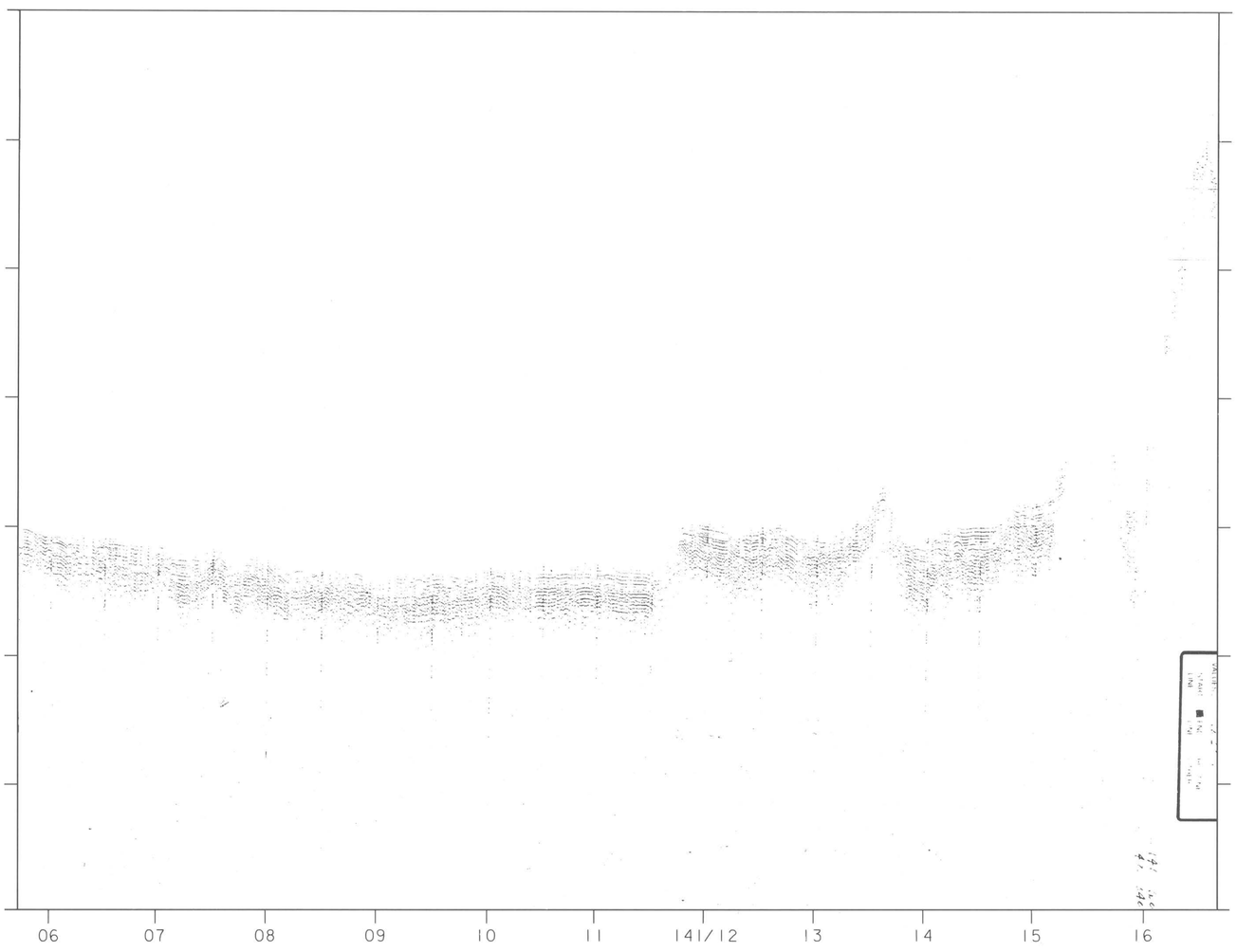
PATTON ESCARPMENT

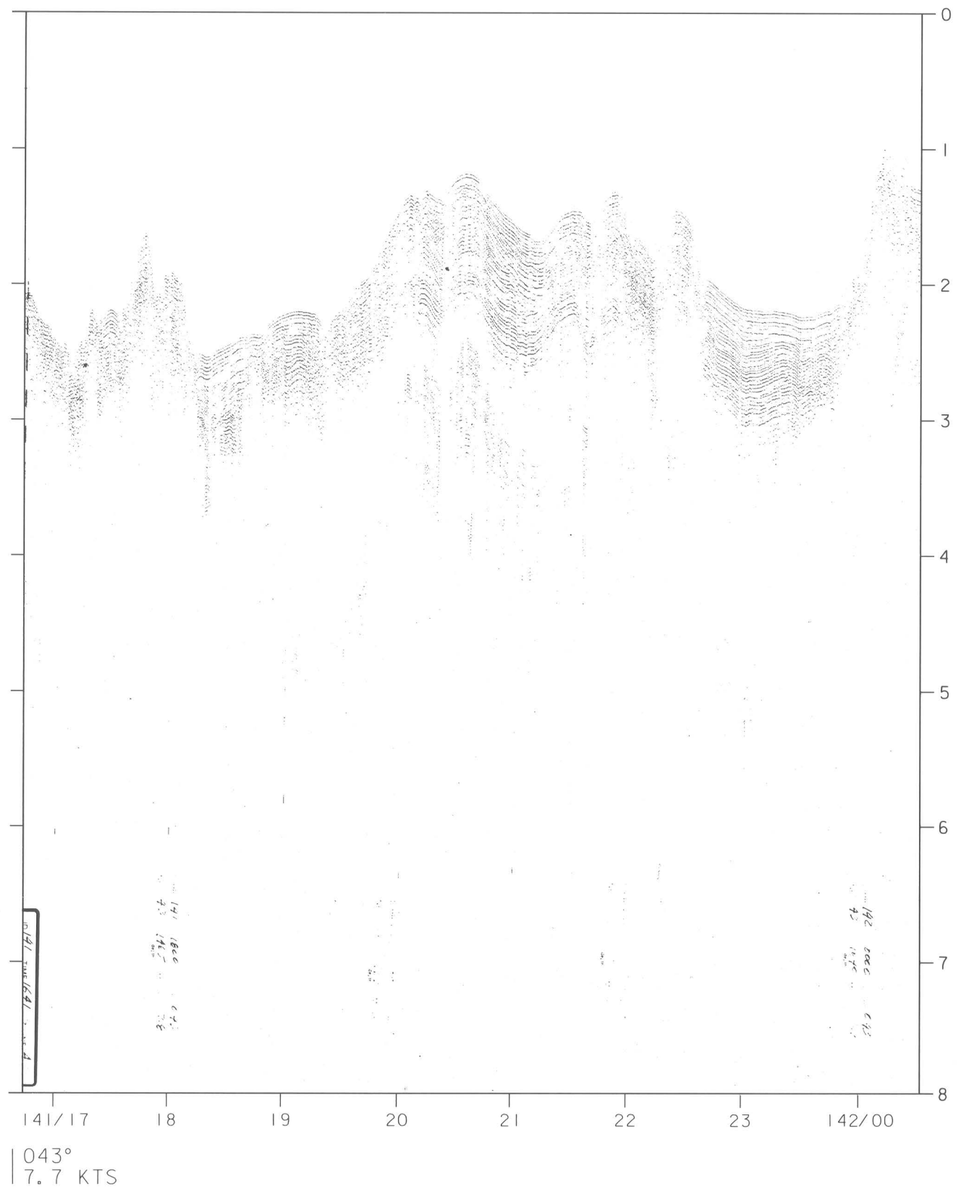




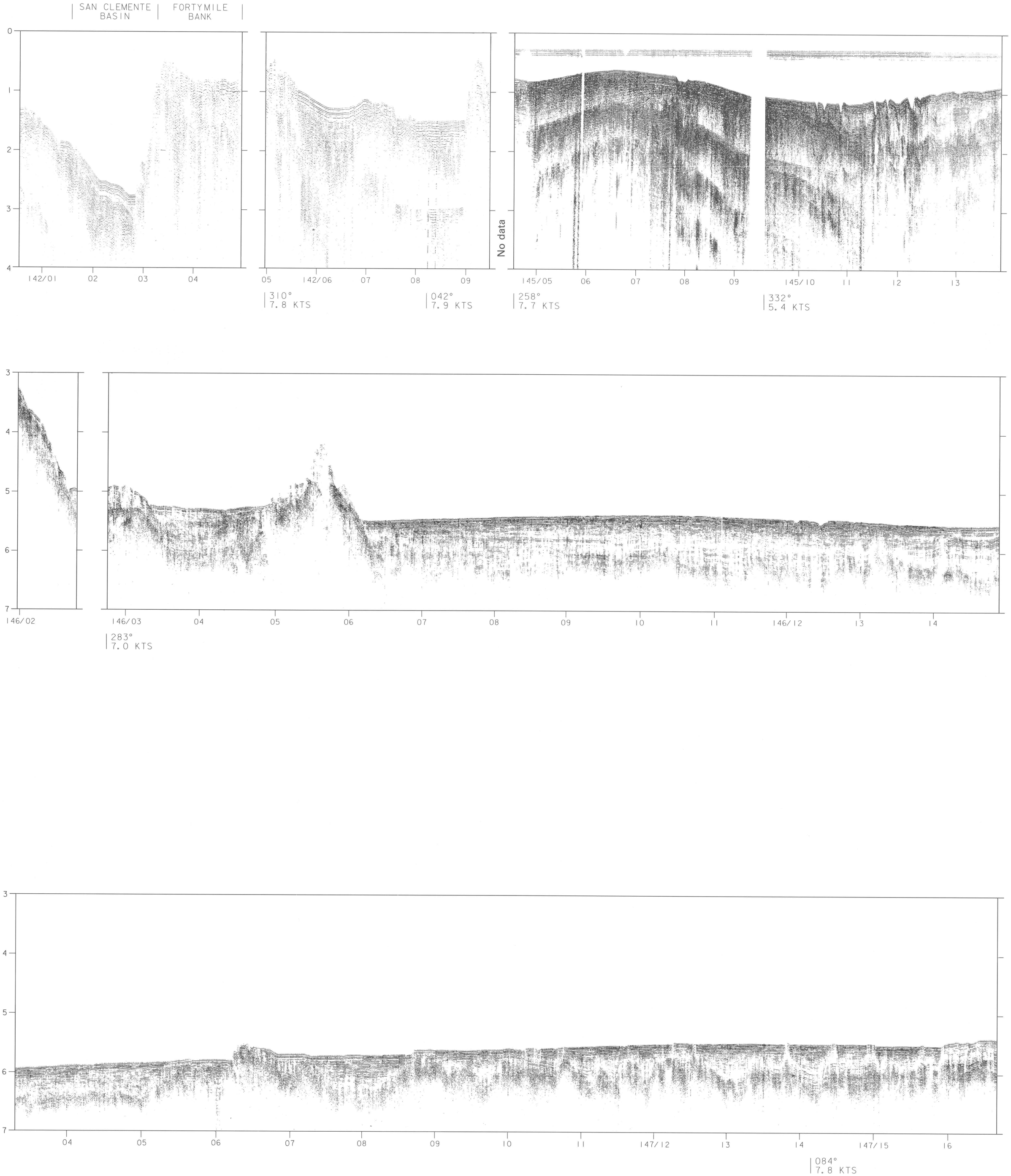
TWO-WAY TRAVELTIME, IN SECONDS

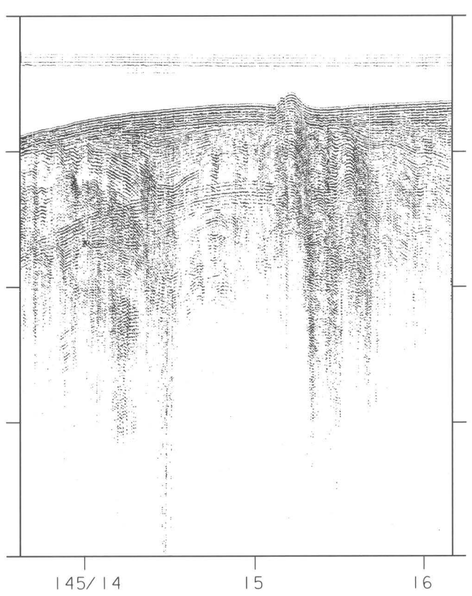
EAST CORTES BASIN



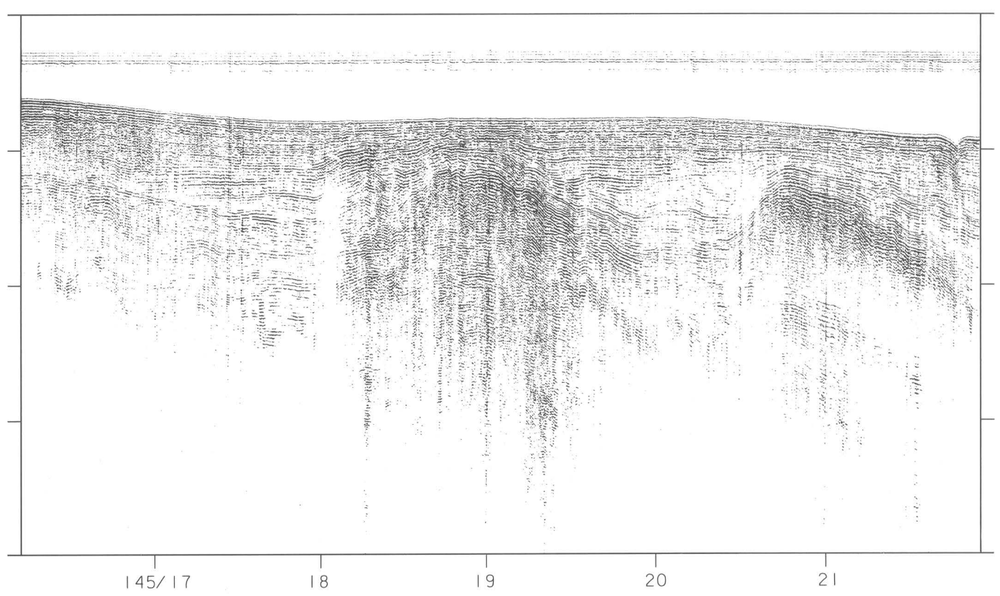


HOURS

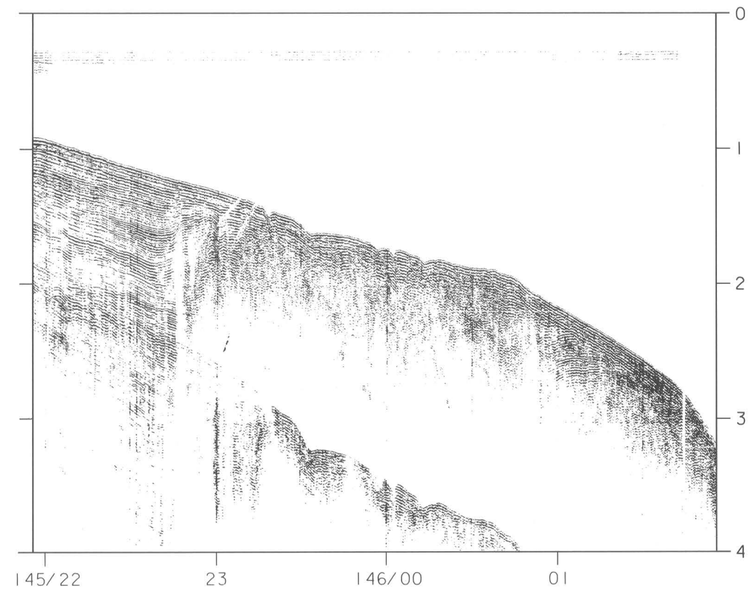

SAN CLEMENTE BASIN
FORTYMILE BANK
TWO-WAY TRAVELTIME, IN SECONDS
0
1
2
3
4
5
6
7
142/01
02
03
04
05
142/06
07
08
09
310°
7.8 KTS
042°
7.9 KTS
No data
145/05
06
07
08
09
145/10
11
12
13
258°
7.7 KTS
332°
5.4 KTS
146/02
146/03
04
05
06
07
08
09
10
11
146/12
13
14
283°
7.0 KTS
147/12
147/15
16
084°
7.8 KTS
HOURS



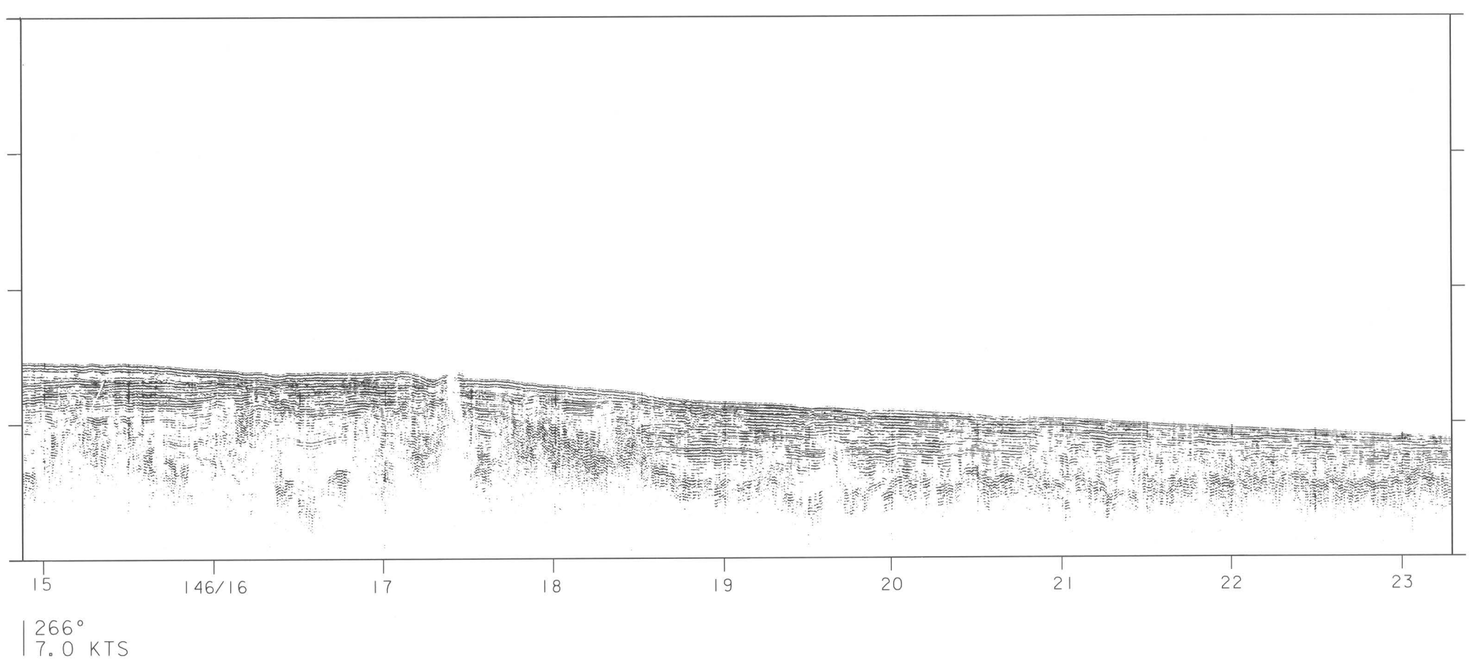
010°
7.2 KTS



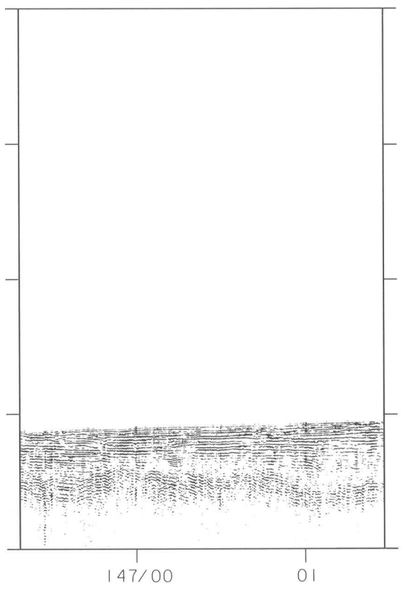
326°
6.7 KTS



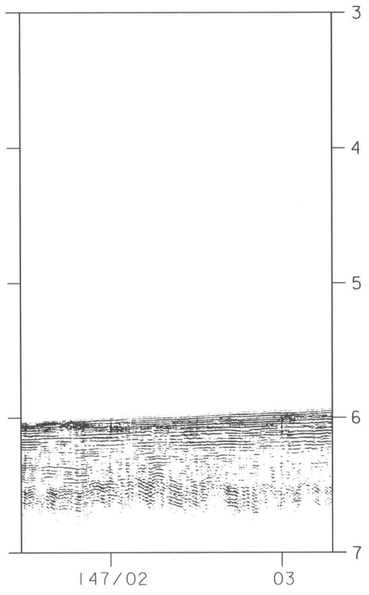
260°
6.0 KTS



266°
7.0 KTS



150°
8.0 KTS

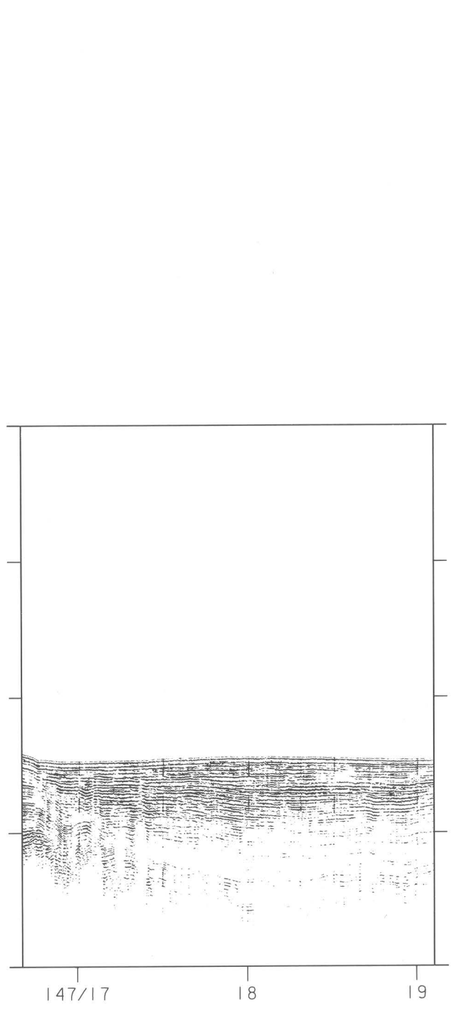


084°
7.8 KTS

TWO-WAY TRAVELTIME, IN SECONDS

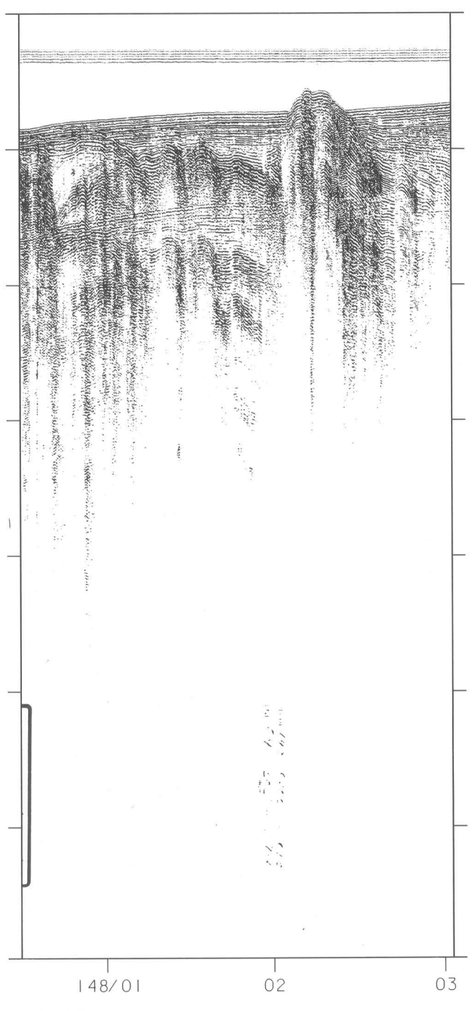
SANTA LUCIA ESCARPMENT

SANTA LUCIA BANK

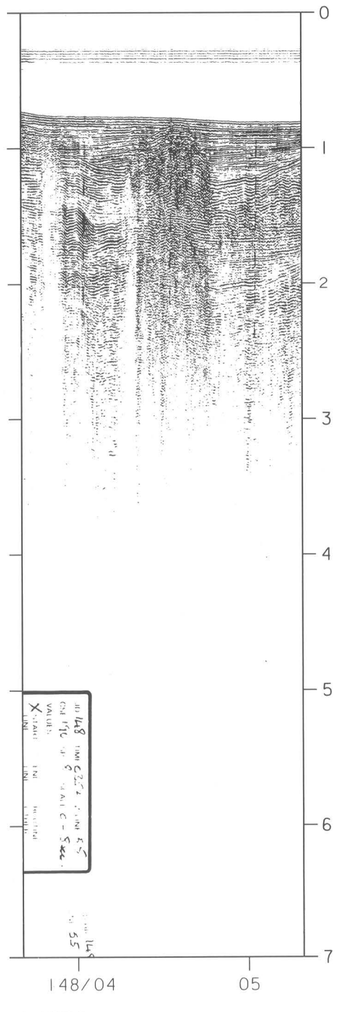




090°
8.0 KTS

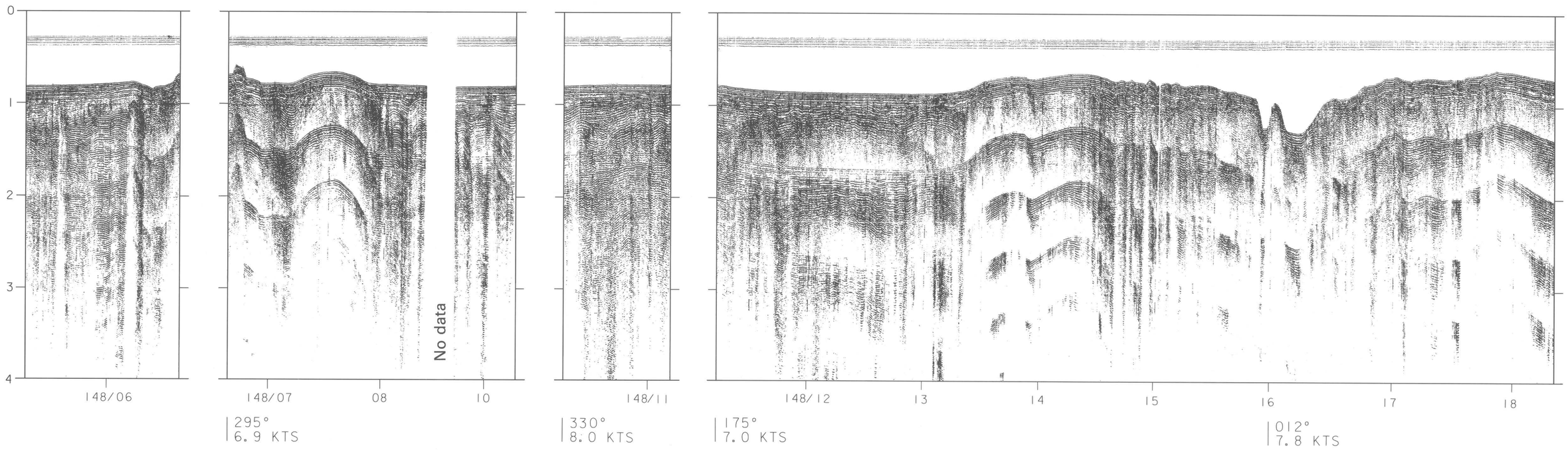


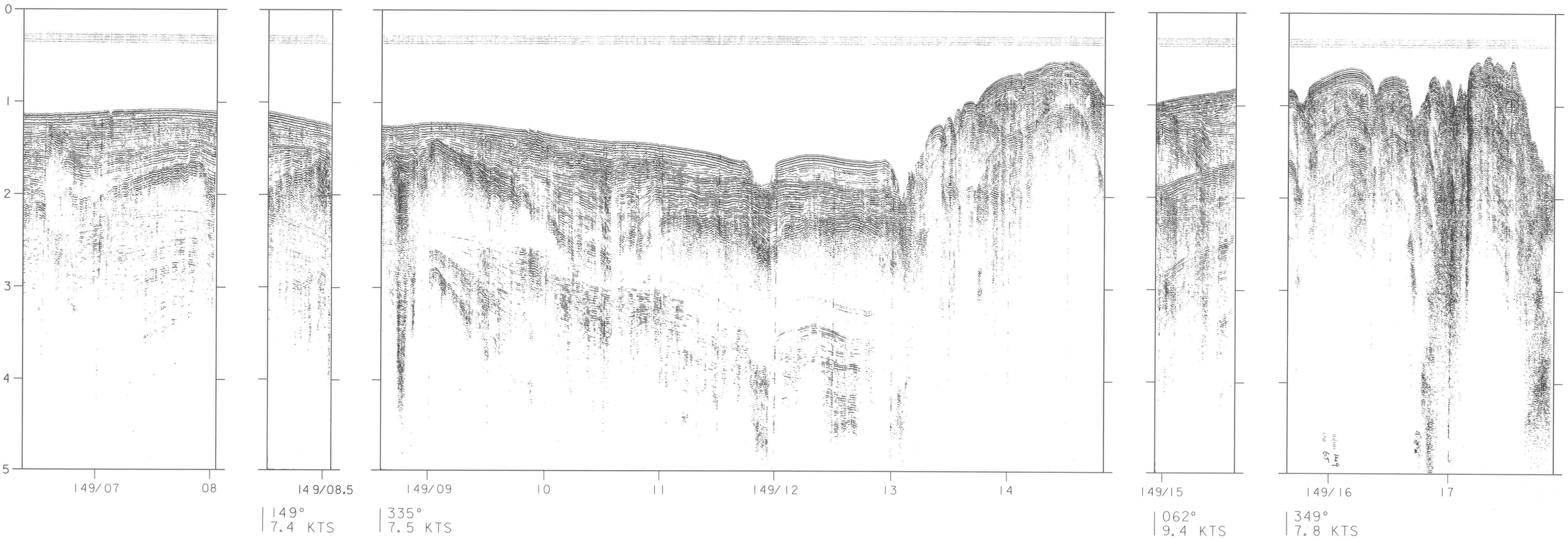
012°
8.0 KTS

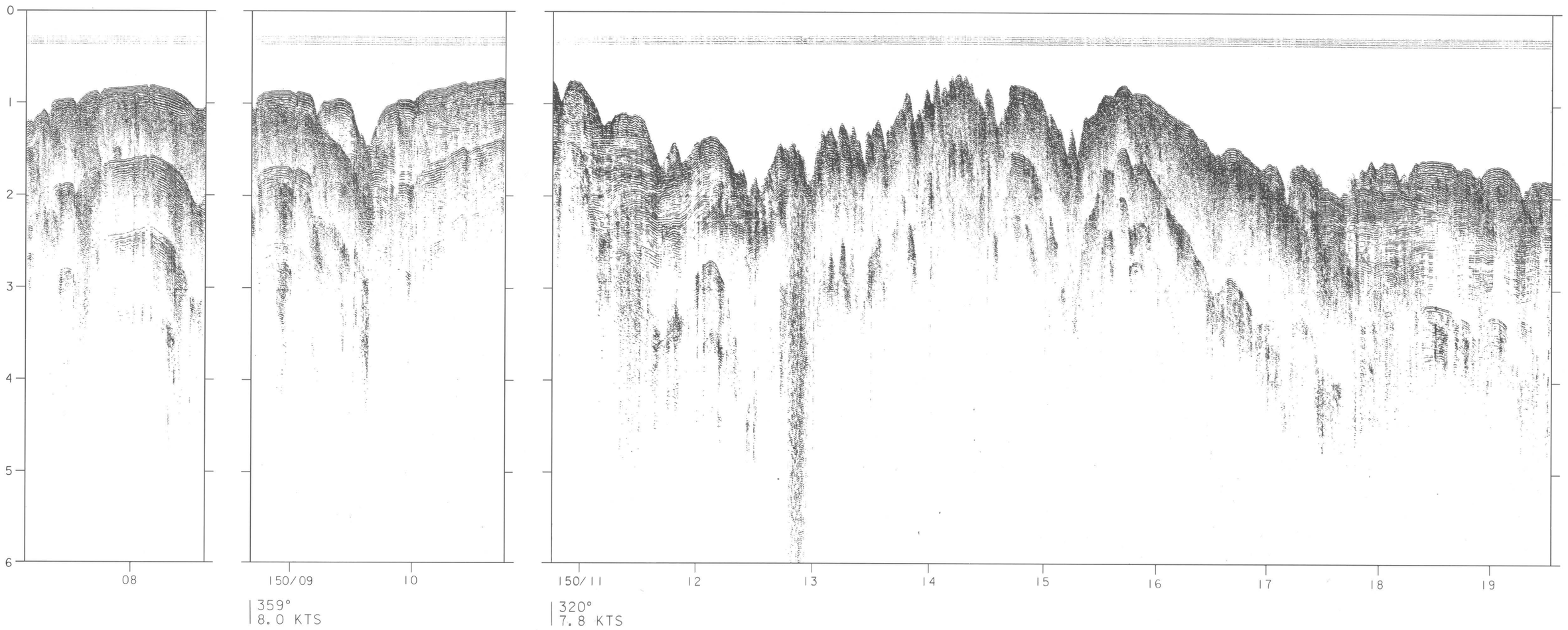


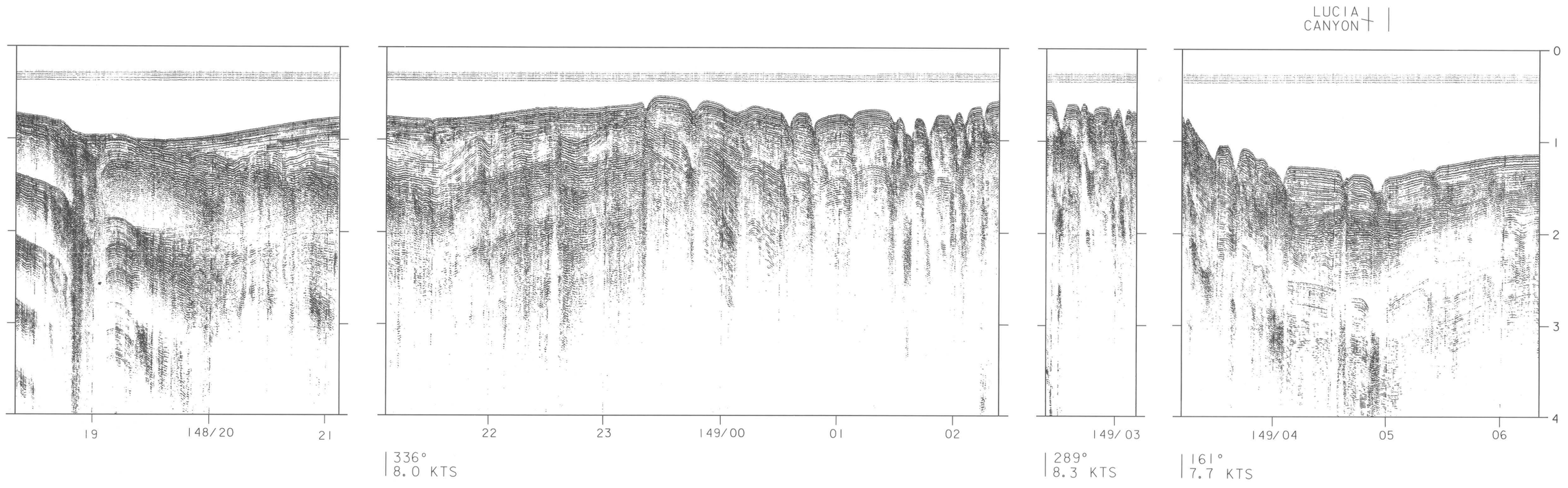
190°
8.0 KTS

HOURS

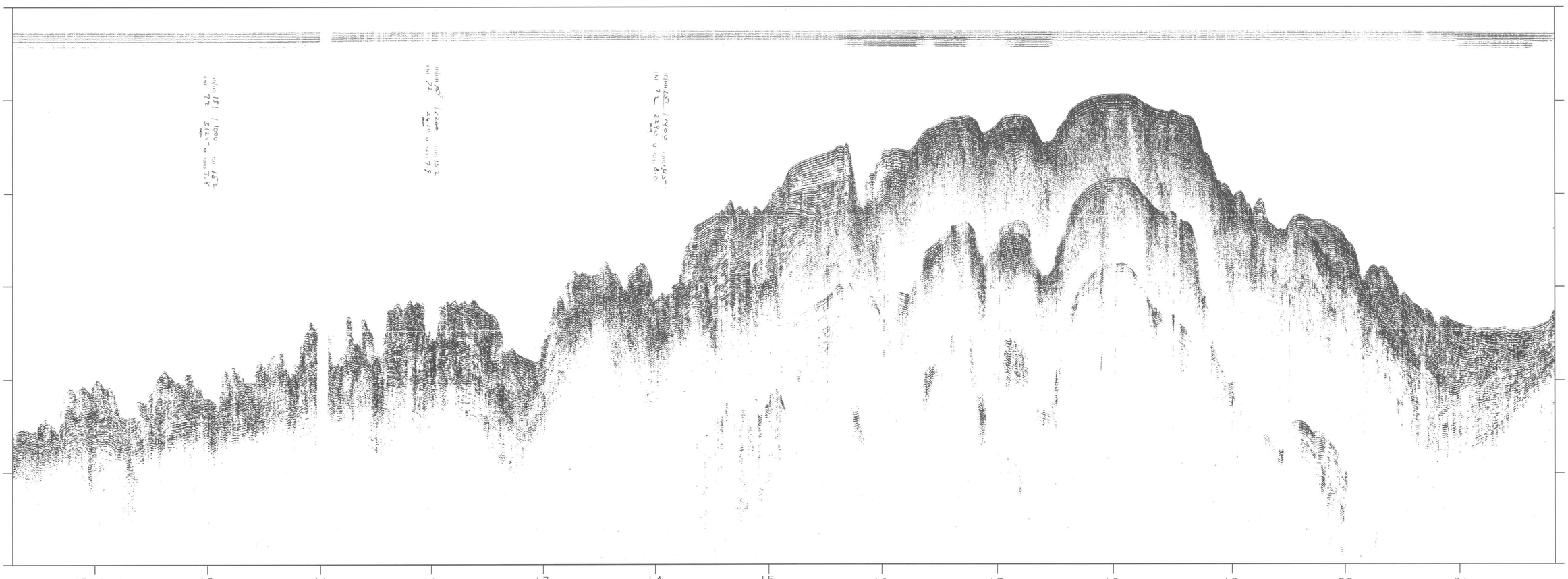

0
1
2
3
4
148/06
148/07
08
10
No data
148/11
148/12
13
14
15
16
17
18
295°
6.9 KTS
330°
8.0 KTS
175°
7.0 KTS
012°
7.8 KTS
LUCIA CANYON
SUR CANYON
MONTEREY CANYON


TWO-WAY TRAVELTIME, IN SECONDS
0
1
2
3
4
5
149/07
08
149/08.5
149/09
10
11
149/12
13
14
149/15
149/16
17
149°
7.4 KTS
335°
7.5 KTS
062°
9.4 KTS
349°
7.8 KTS
PIONEER CANYON
BODEGA CANYON

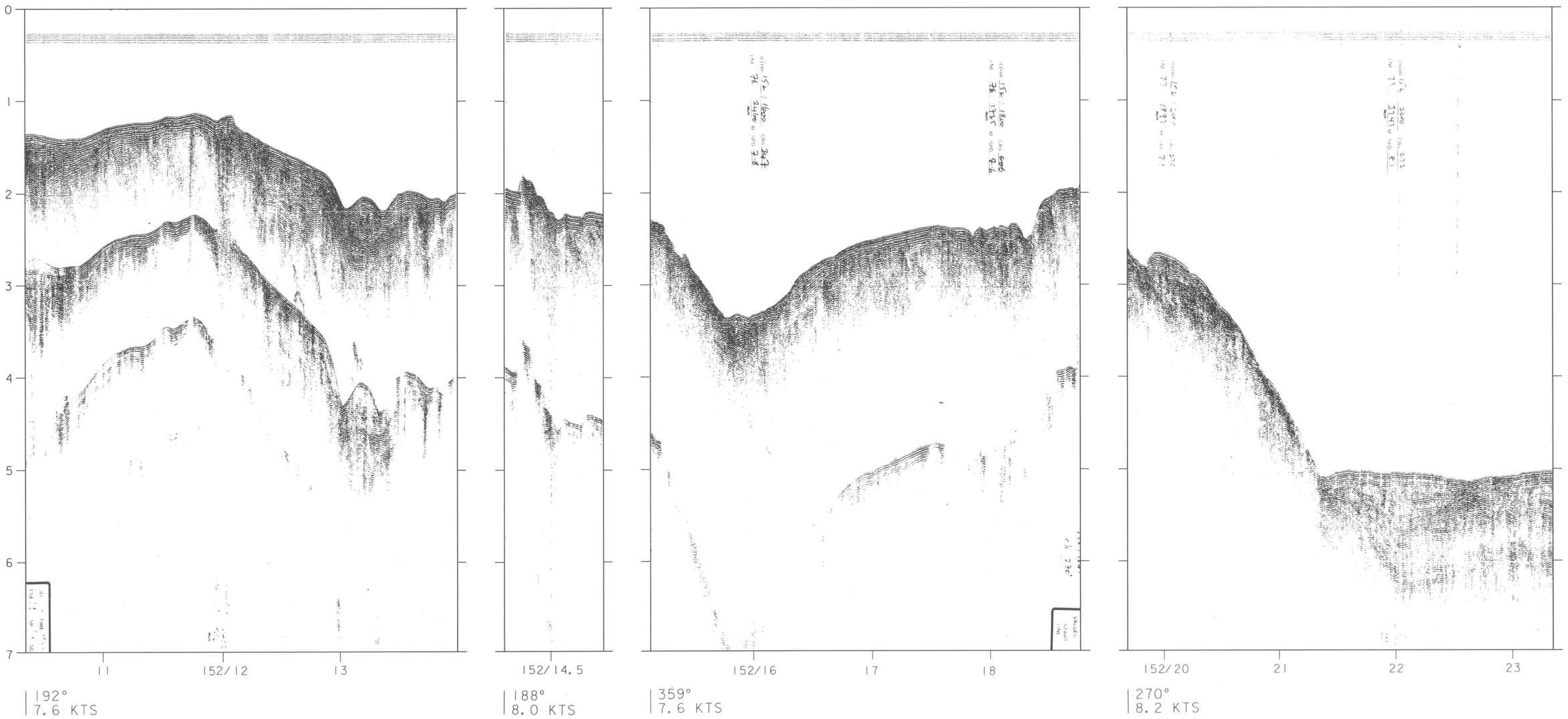

0
1
2
3
4
5
6
08
150/09
10
150/11
12
13
14
15
16
17
18
19
359°
8.0 KTS
320°
7.8 KTS
HOURS


LUCIA CANYON
MONTEREY CANYON
MONTEREY CANYON
ASCENSION CANYON
19
148/20
21
22
23
149/00
01
02
149/03
149/04
05
06
336°
8.0 KTS
289°
8.3 KTS
161°
7.7 KTS
149/18
19
20
21
22
23
150/00
150/02
03
04
05
06
07
310°
7.8 KTS
140°
8.1 KTS
319°
7.2 KTS
No data
150/20
21
22
23
151/00
01
151/02
03
04
05
06
07
08
333°
8.1 KTS
262°
7.8 KTS
134°
7.9 KTS
No data
0
1
2
3
4
5
6
TWO-WAY TRAVELTIME, IN SECONDS
HOURS

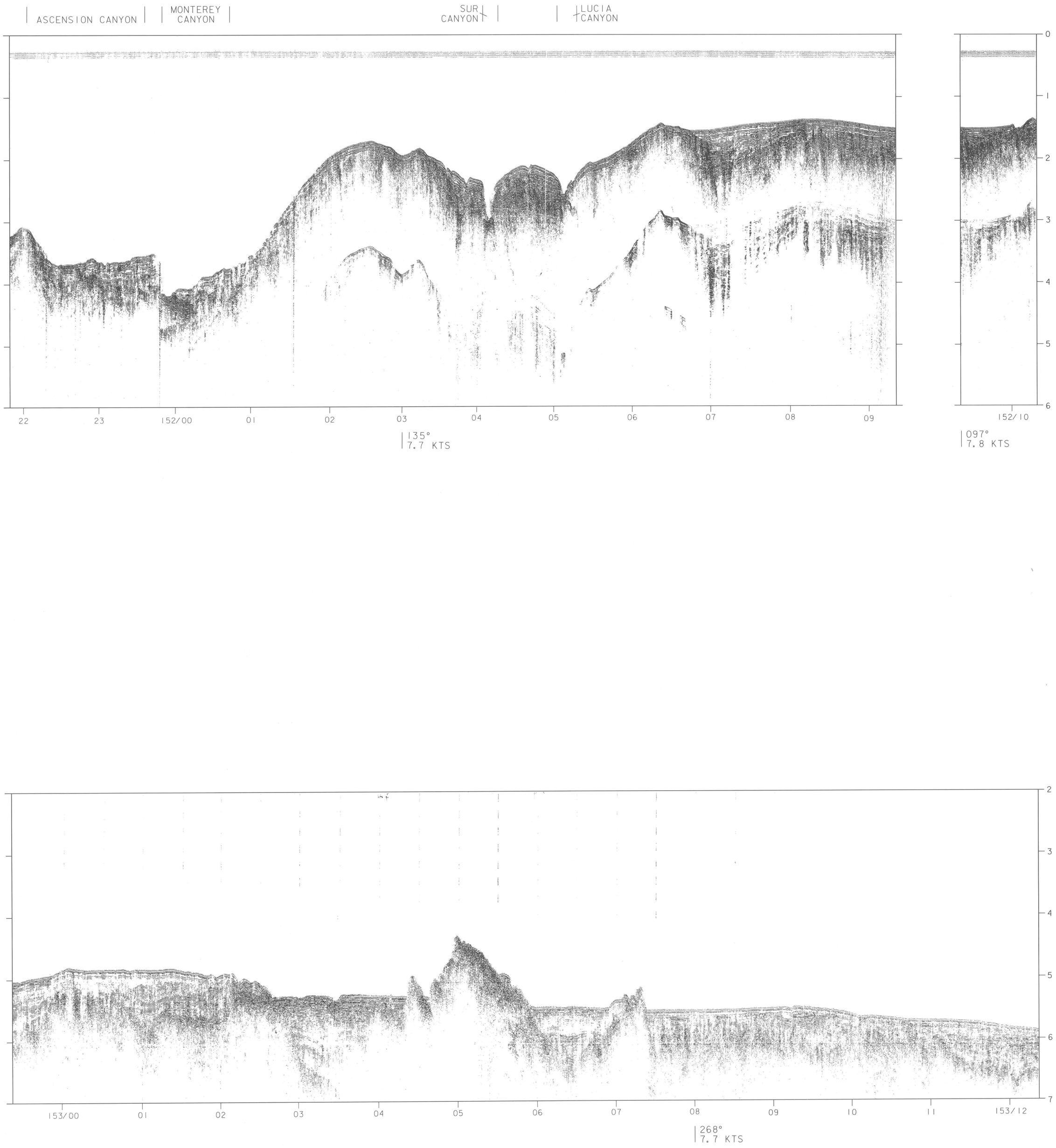
PIONEER CANYON



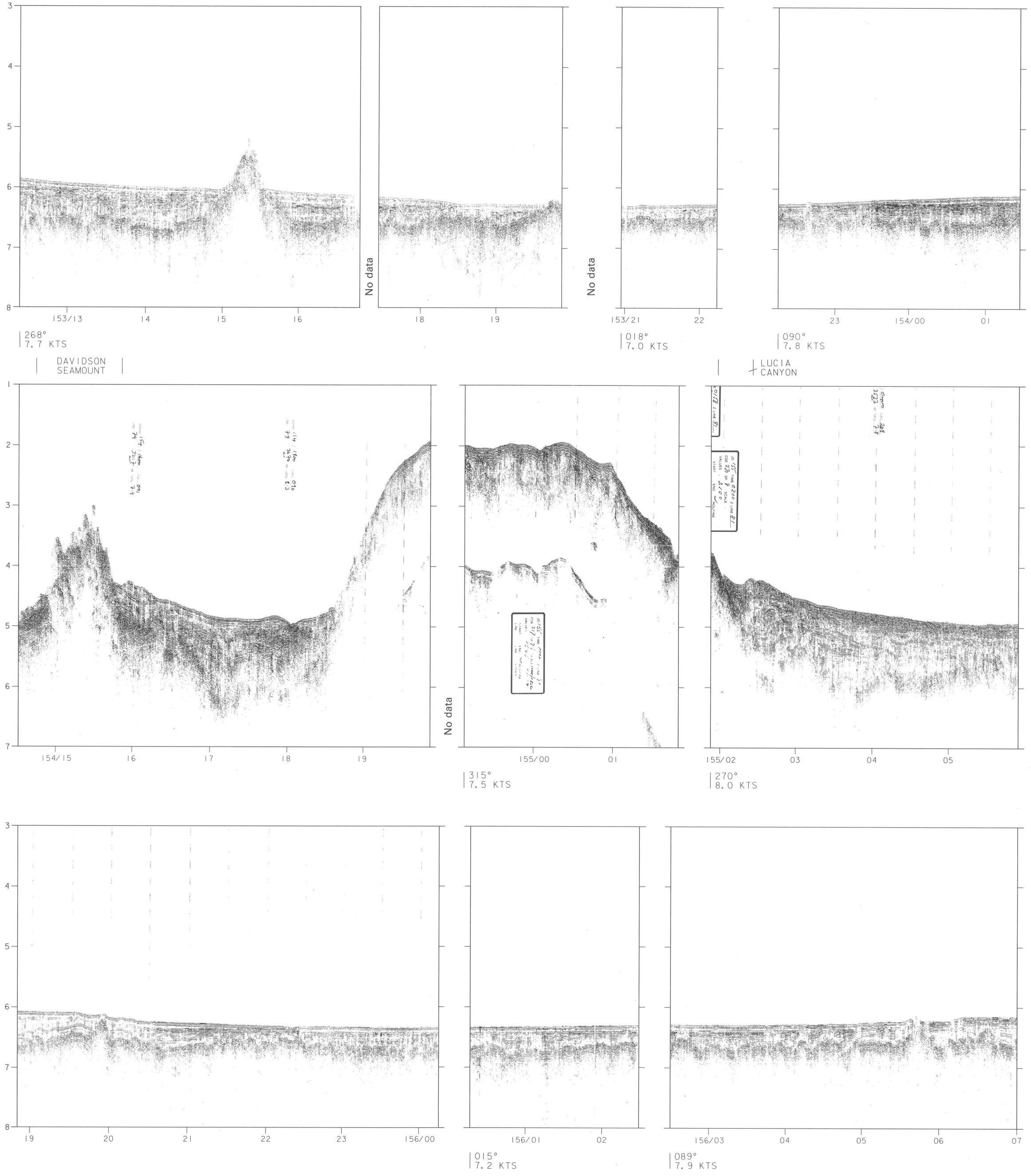
TWO-WAY TRAVELTIME, IN SECONDS

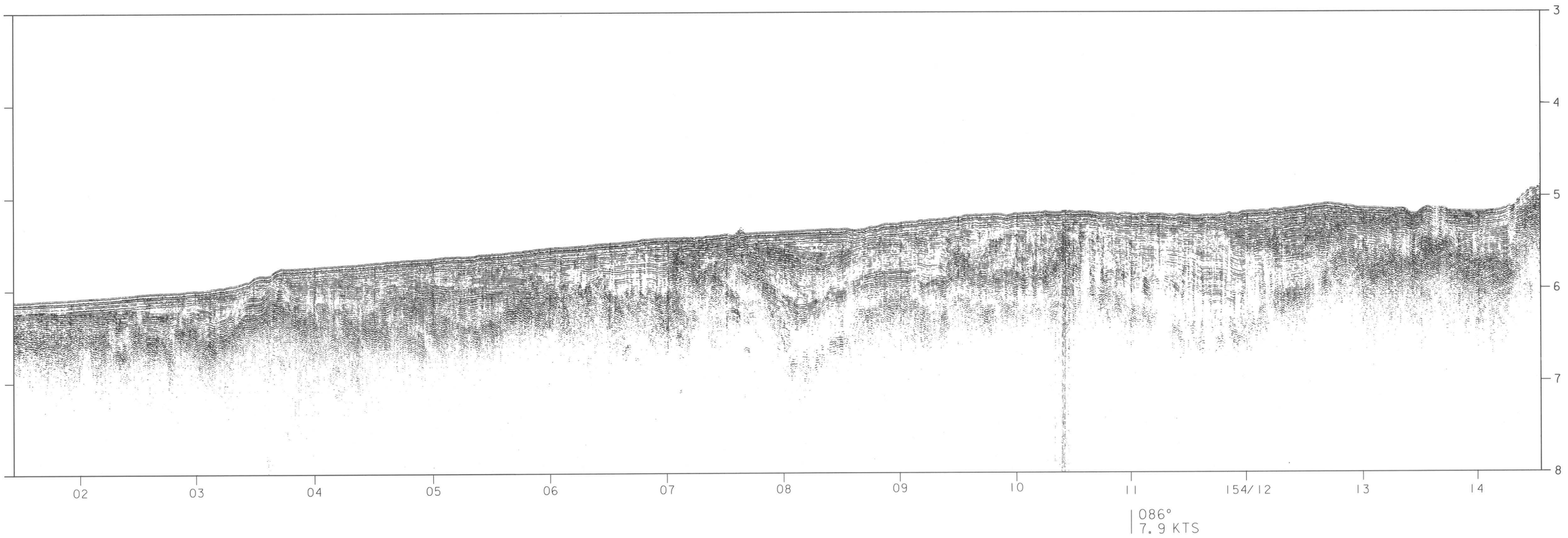


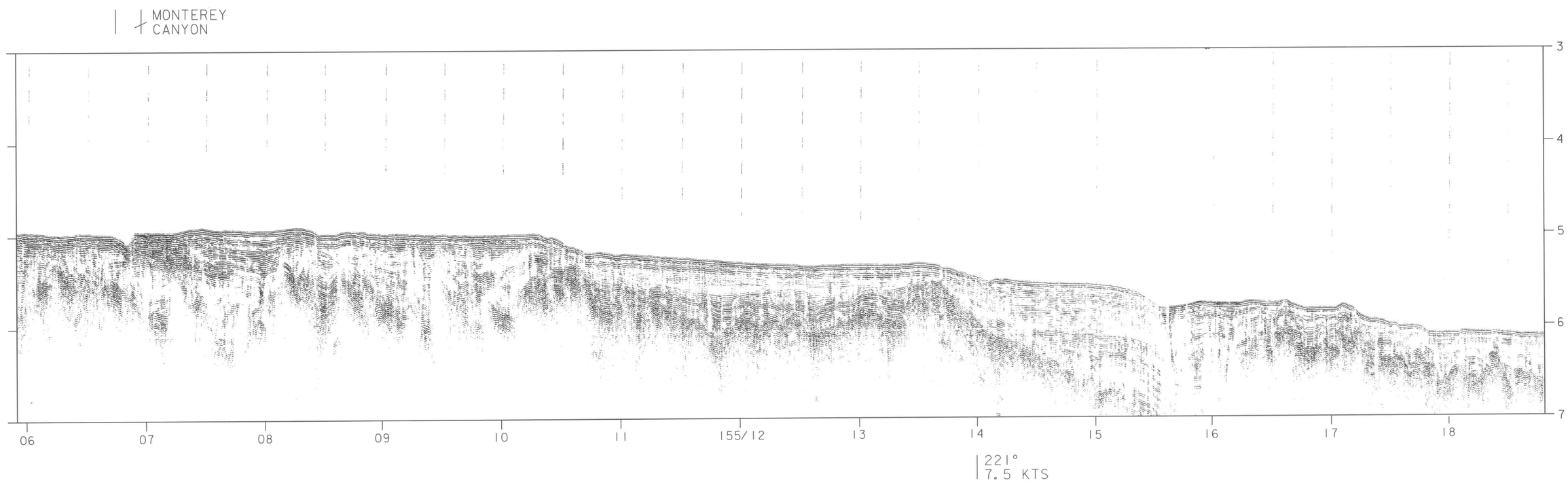
HOURS


ASCENSION CANYON
MONTEREY CANYON
SUR CANYON
LUCIA CANYON
0
1
2
3
4
5
6
22
23
152/00
01
02
03
04
05
06
07
08
09
152/10
135°
7.7 KTS
097°
7.8 KTS
TWO-WAY TRAVELTIME, IN SECONDS
2
3
4
5
6
7
153/00
01
02
03
04
05
06
07
08
09
10
11
153/12
268°
7.7 KTS

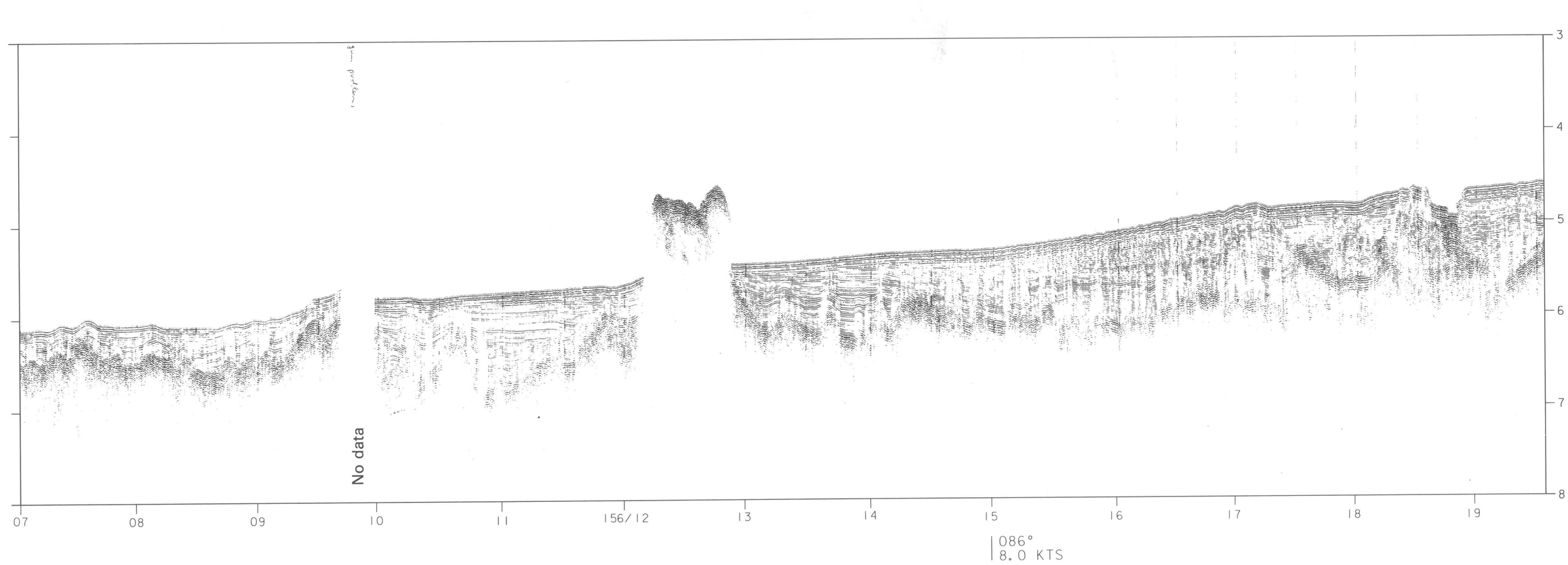
HOURS


TWO-WAY TRAVELTIME, IN SECONDS
HOURS
No data
No data
No data
268°
7.7 KTS
DAVIDSON
SEAMOUNT
018°
7.0 KTS
090°
7.8 KTS
LUCIA
CANYON
315°
7.5 KTS
270°
8.0 KTS
015°
7.2 KTS
089°
7.9 KTS

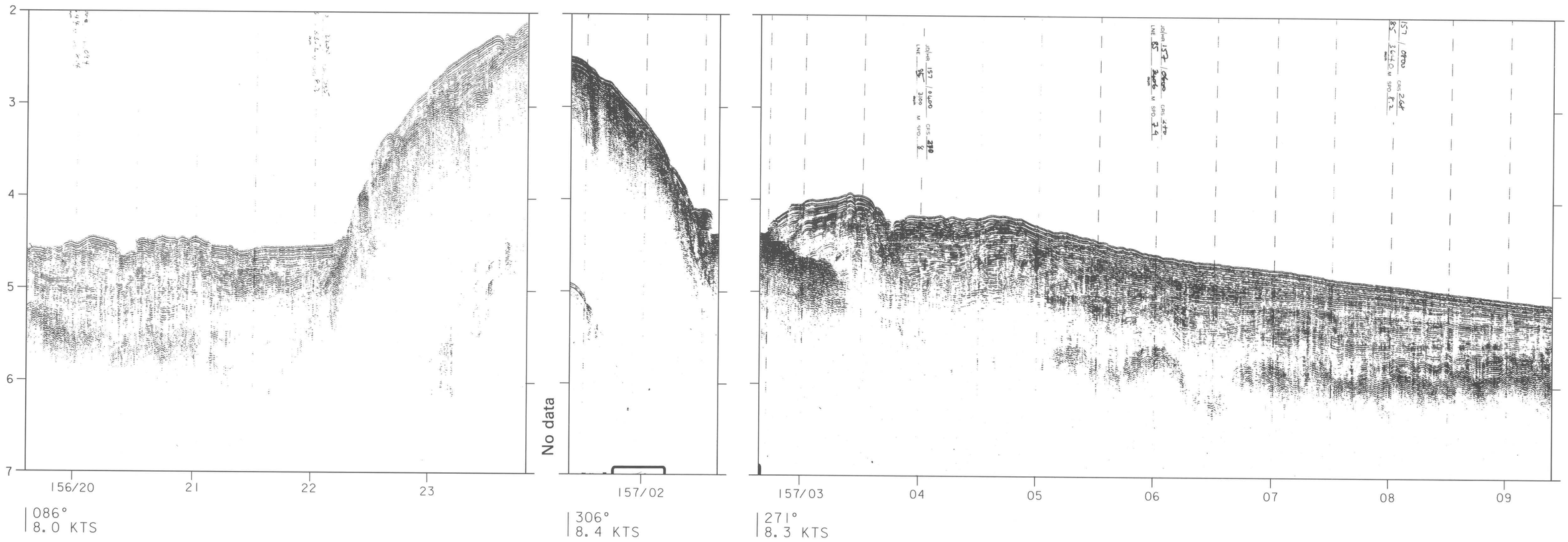


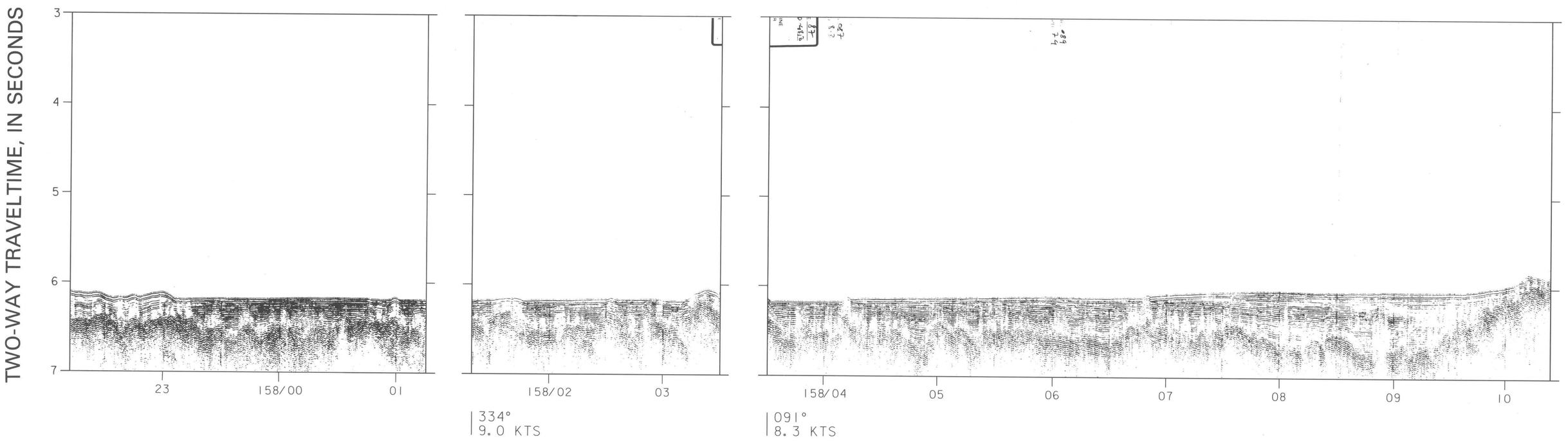


TWO-WAY TRAVELTIME, IN SECONDS

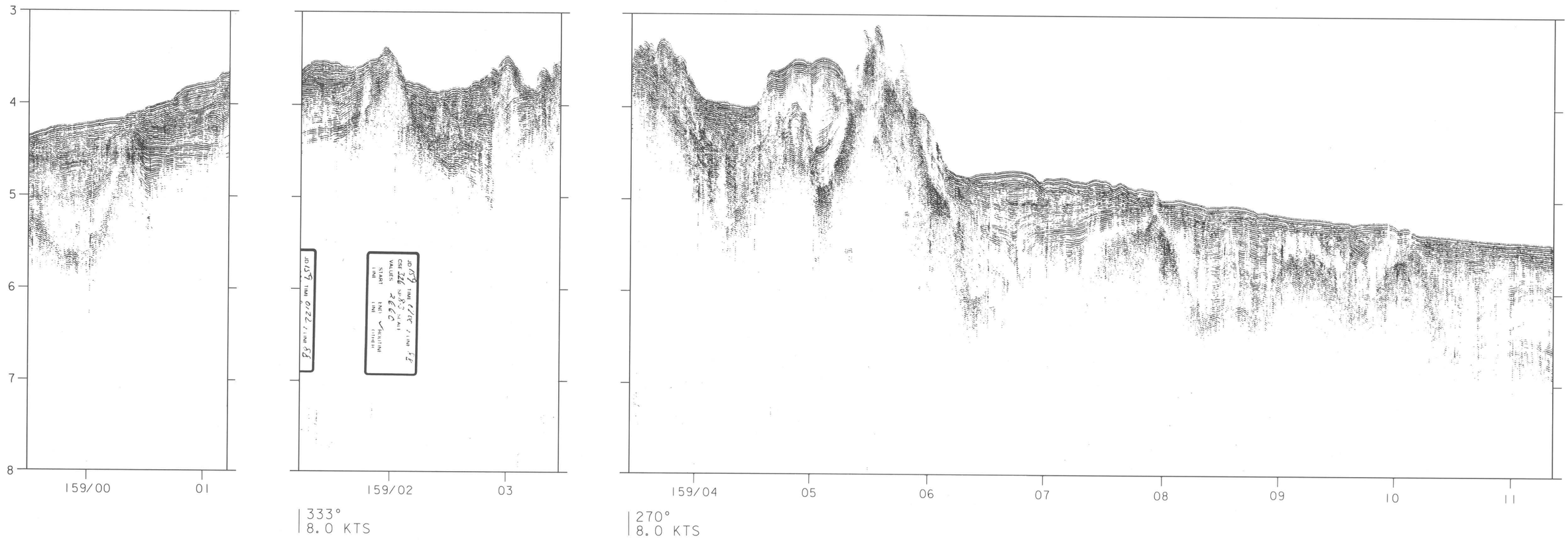


HOURS

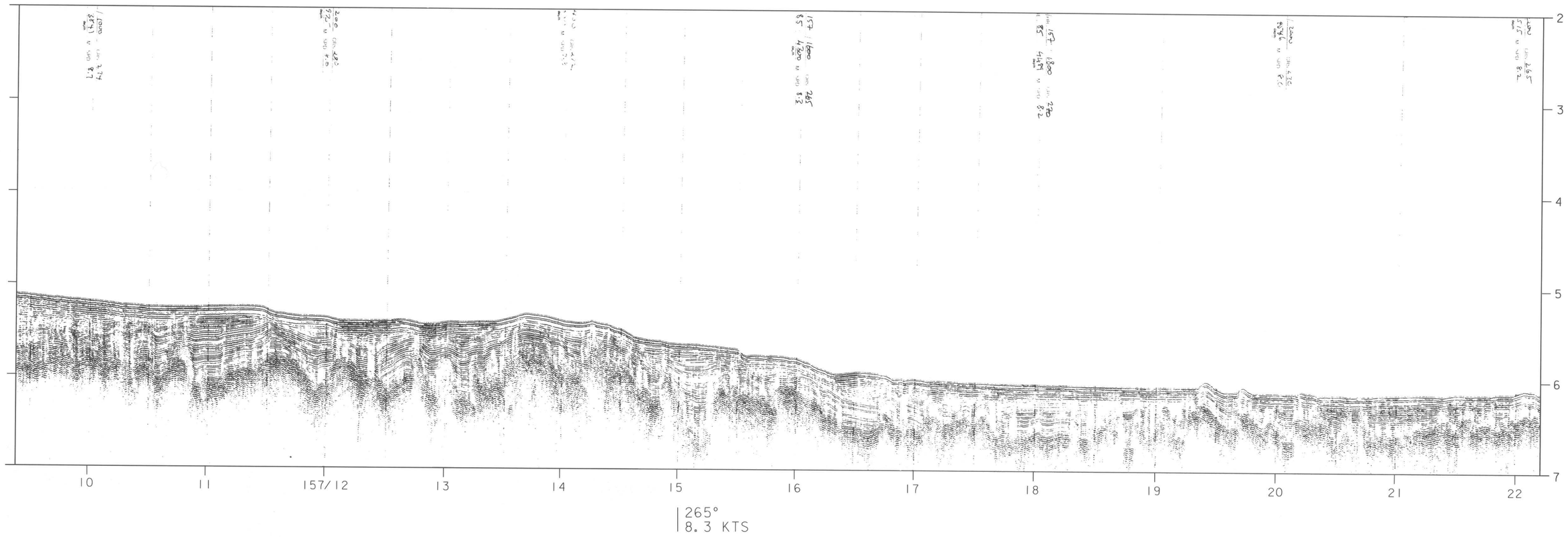


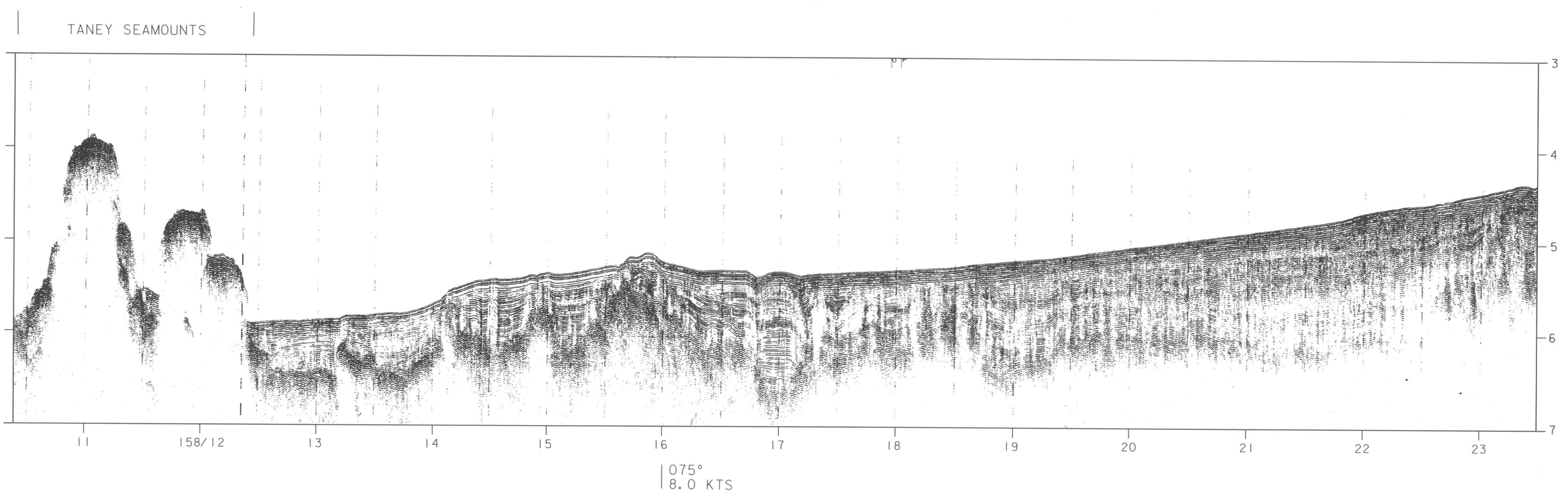


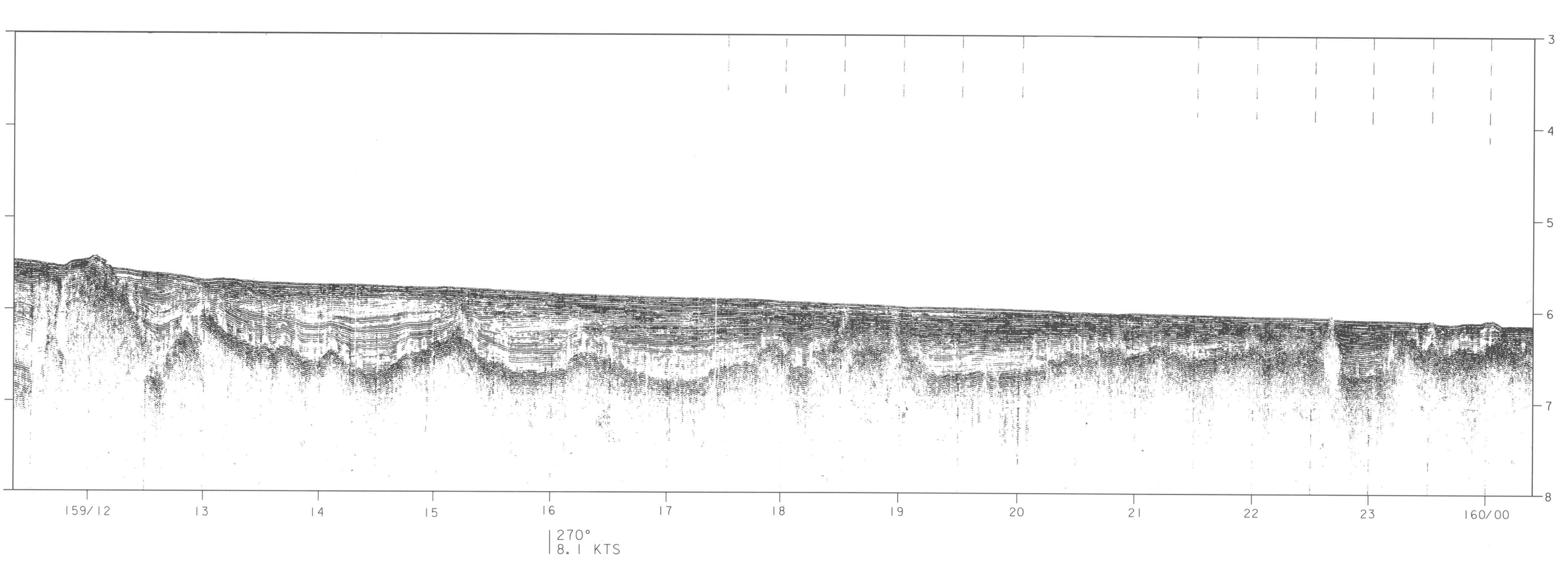
GUIDE SEAMOUNT | PIONEER CANYON



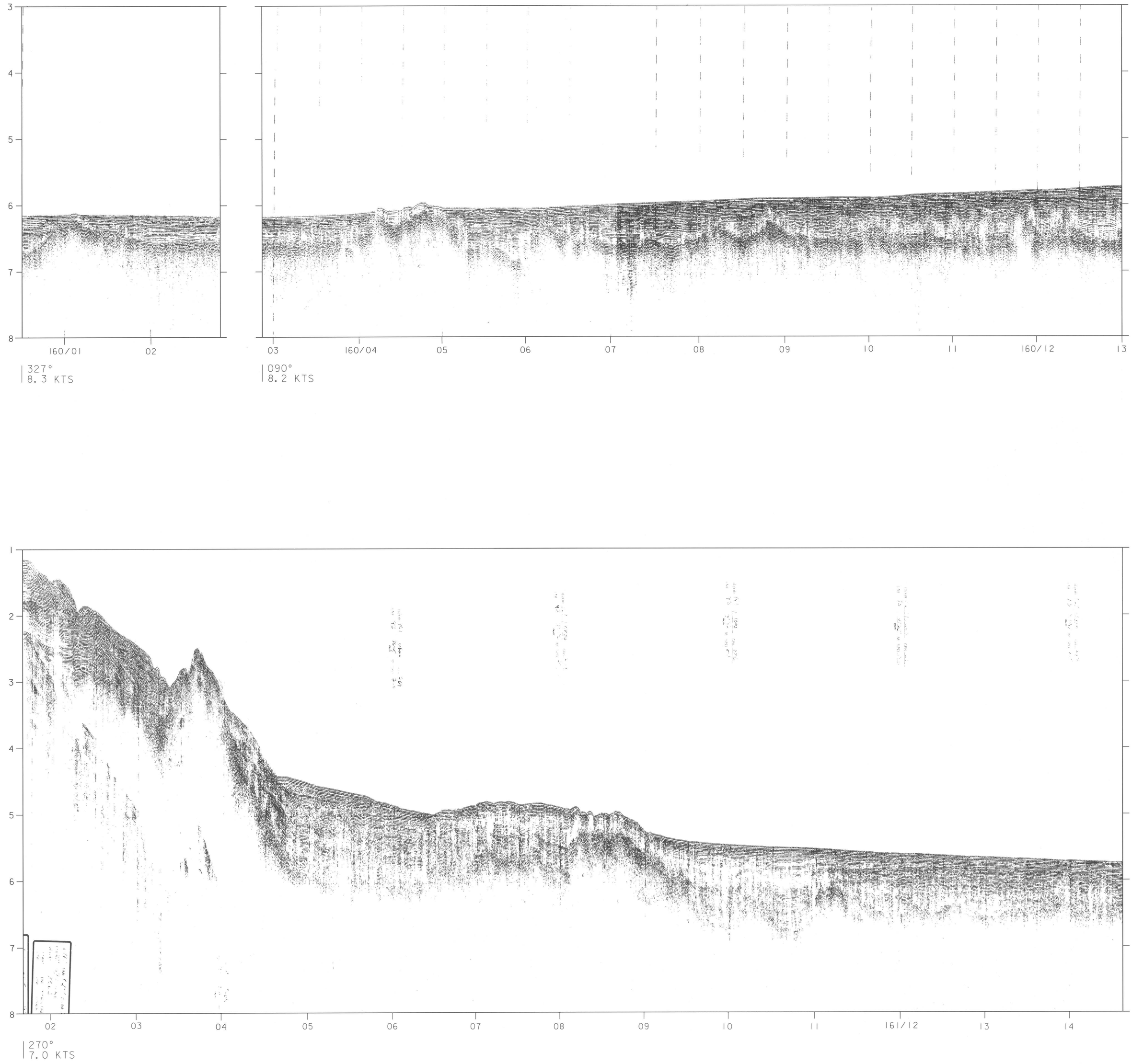
HOURS


2
3
4
5
6
7
10
11
157/12
13
14
15
16
17
18
19
20
21
22
265°
8.3 KTS


TANEY SEAMOUNTS
3
4
5
6
7
11
158/12
13
14
15
16
17
18
19
20
21
22
23
075°
8.0 KTS
TWO-WAY TRAVELTIME, IN SECONDS

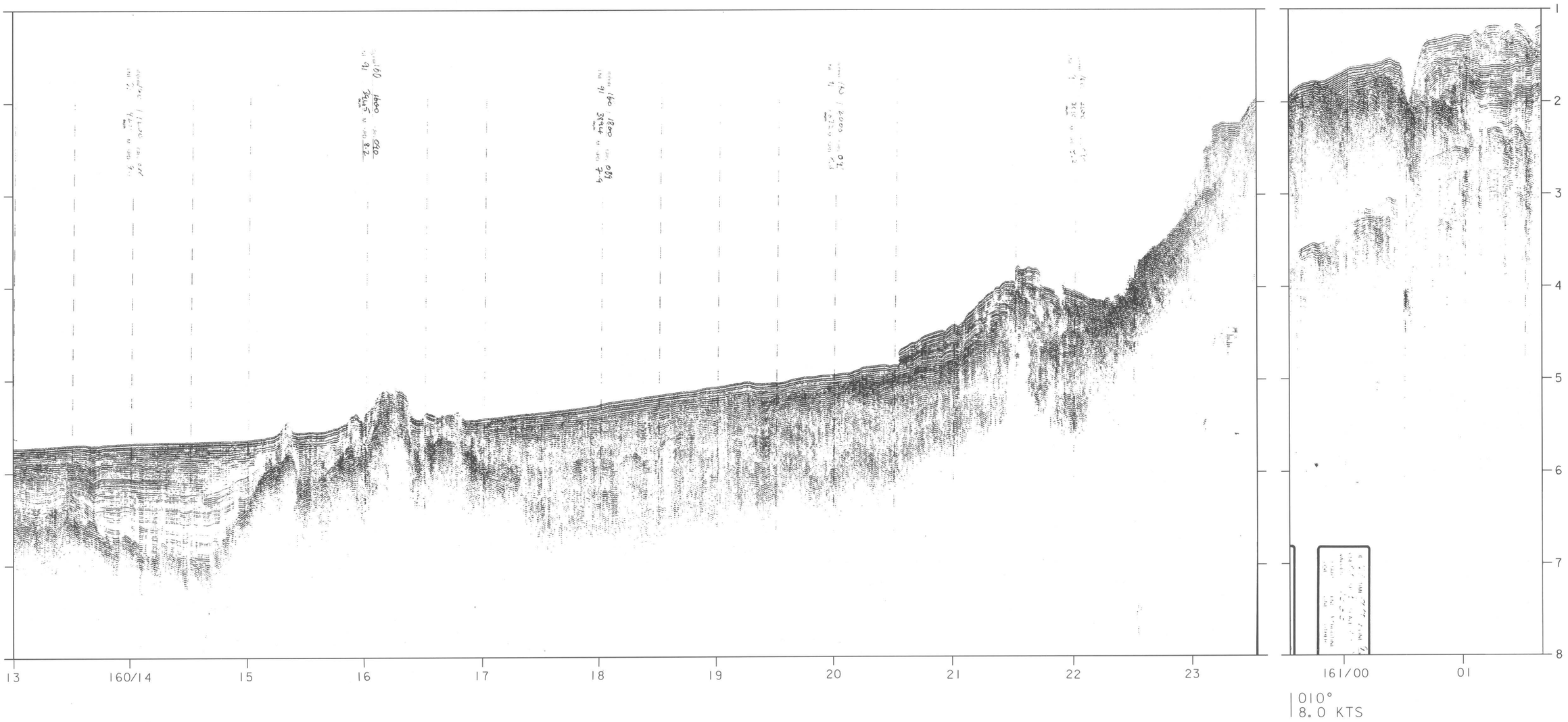

3
4
5
6
7
8
159/12
13
14
15
16
17
18
19
20
21
22
23
160/00
270°
8.1 KTS

HOURS

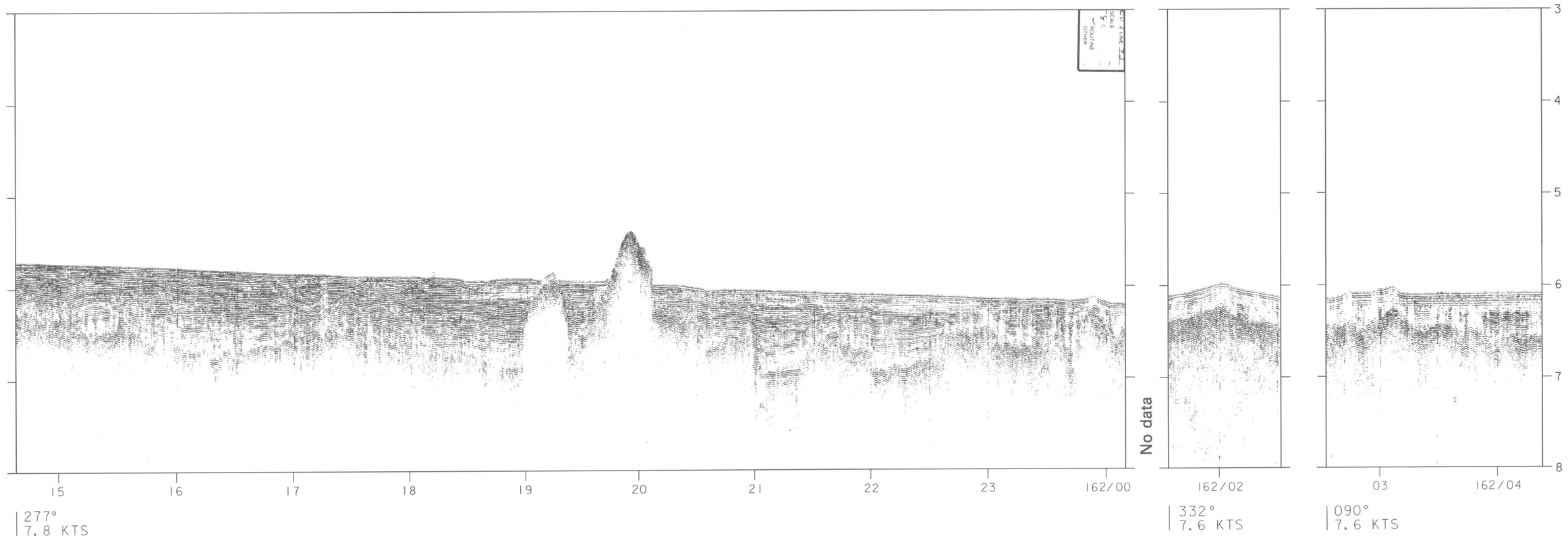

TWO-WAY TRAVELTIME, IN SECONDS
3
4
5
6
7
8
160/01
02
03
160/04
05
06
07
08
09
10
11
160/12
13
327°
8.3 KTS
090°
8.2 KTS
1
2
3
4
5
6
7
8
02
03
04
05
06
07
08
09
10
11
161/12
13
14
270°
7.0 KTS

HOURS

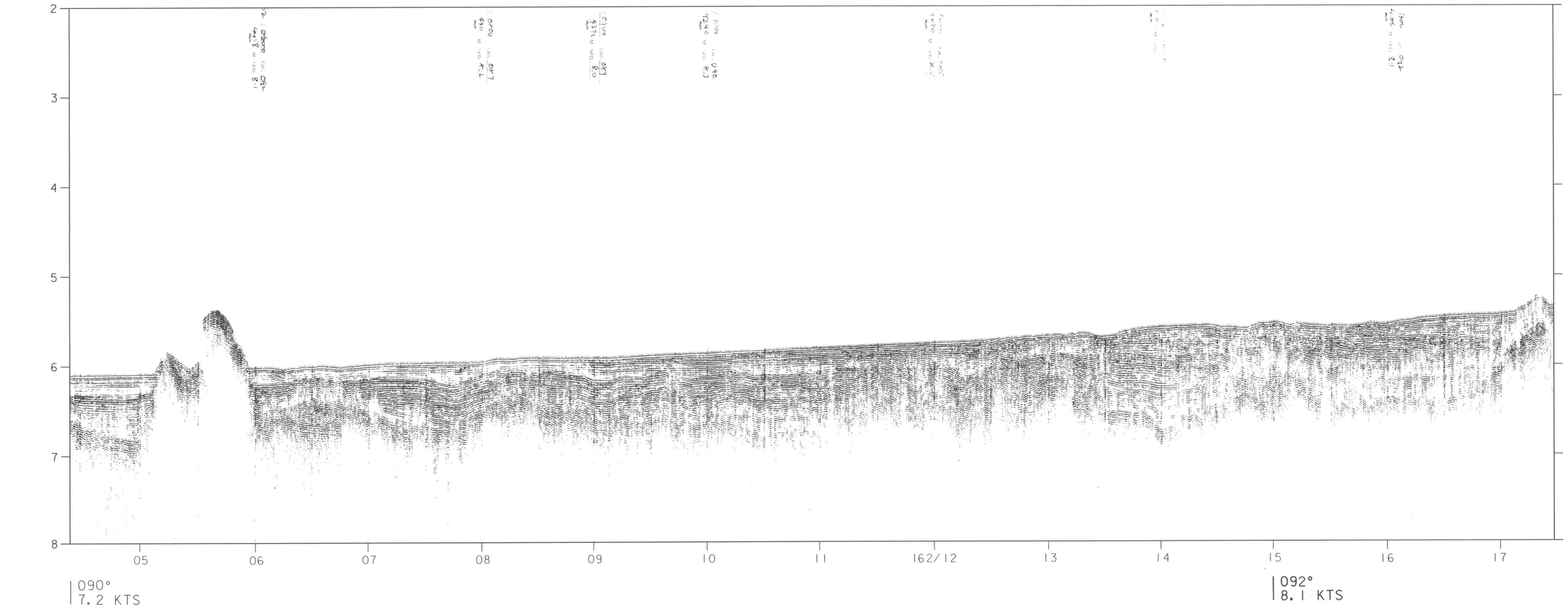
PIONEER CANYON

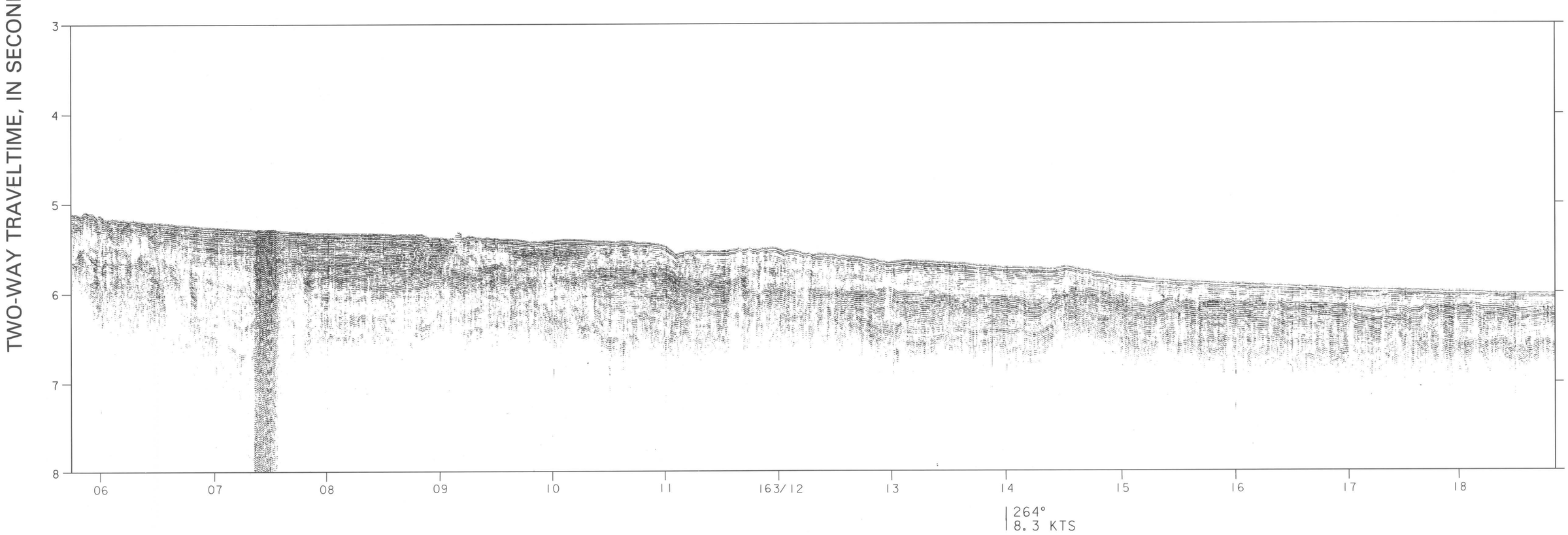


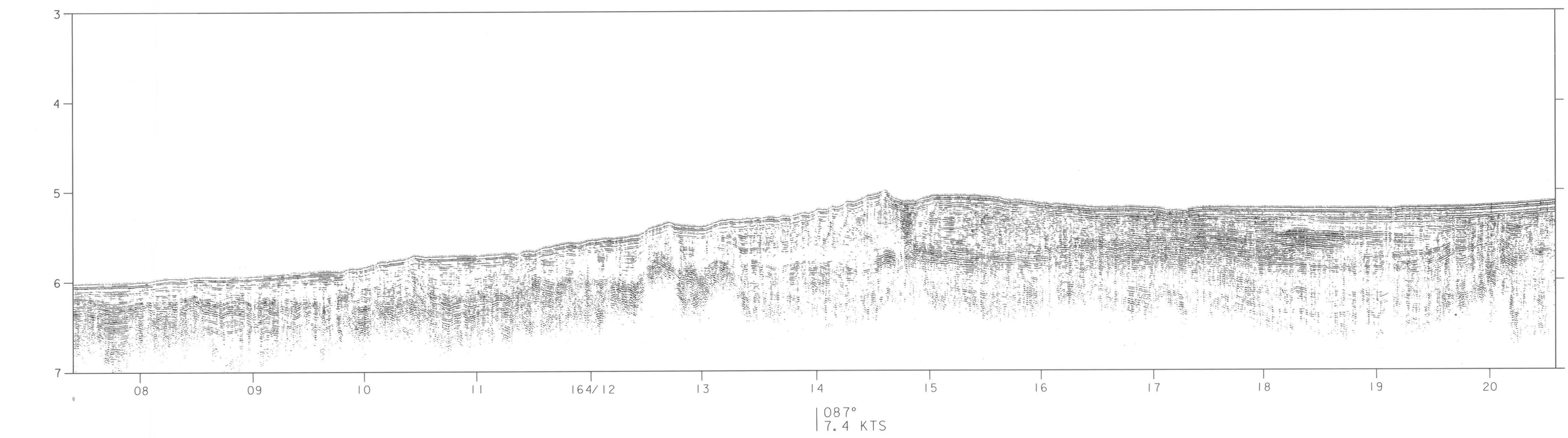
TWO-WAY TRAVELTIME, IN SECONDS



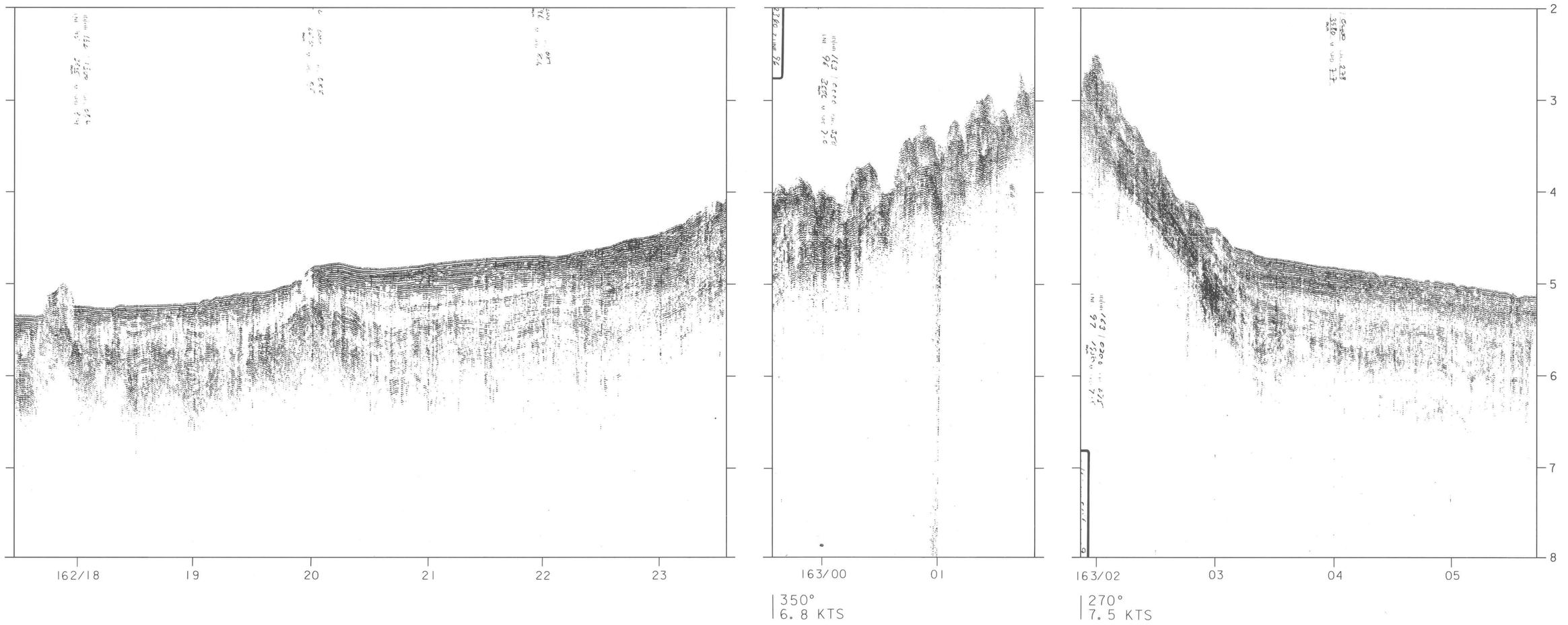
HOURS

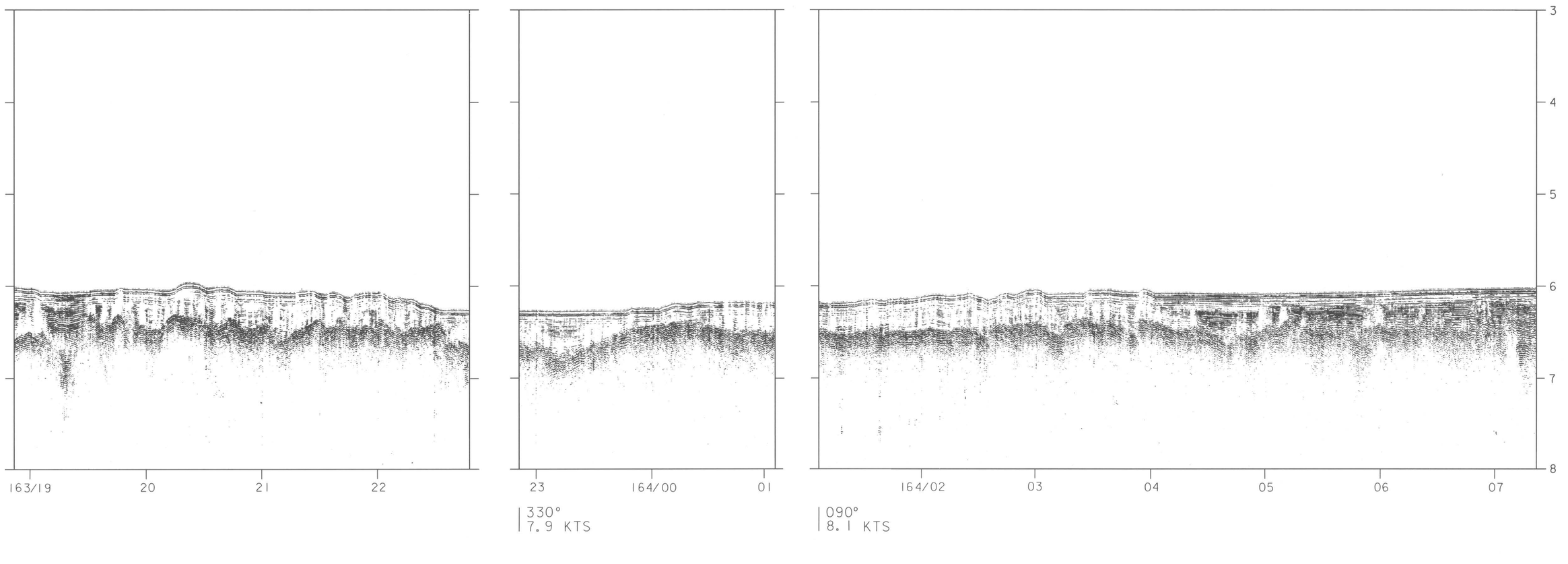

2
3
4
5
6
7
8
05
06
07
08
09
10
11
162/12
13
14
15
16
17
090°
7.2 KTS
092°
8.1 KTS

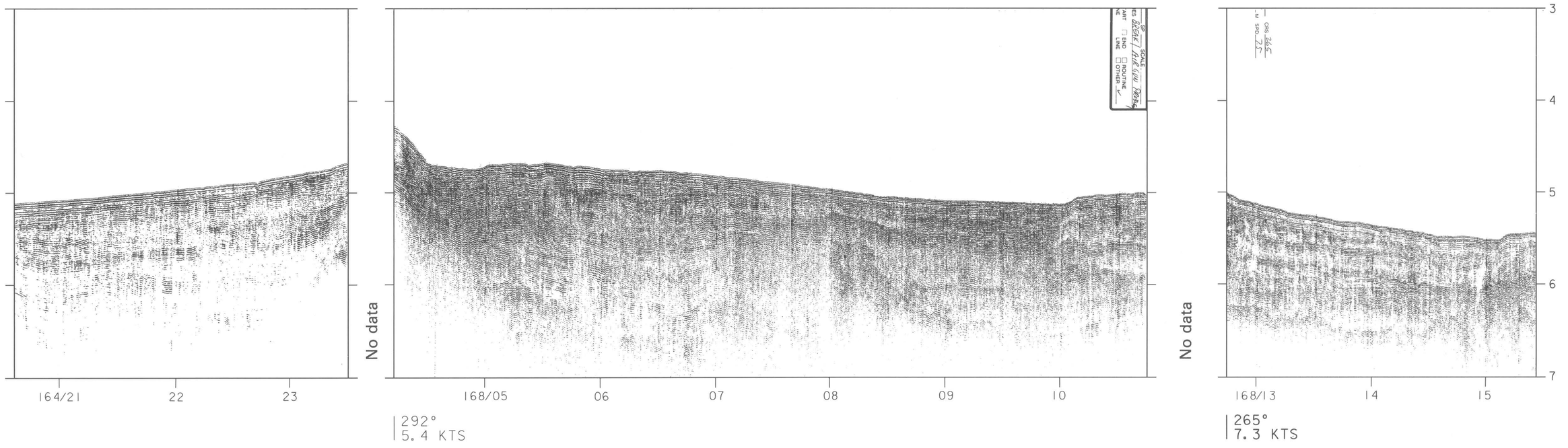

TWO-WAY TRAVELTIME, IN SECONDS
3
4
5
6
7
8
06
07
08
09
10
11
163/12
13
14
15
16
17
18
264°
8.3 KTS


3
4
5
6
7
08
09
10
11
164/12
13
14
15
16
17
18
19
20
087°
7.4 KTS

HOURS


2
3
4
5
6
7
8
162/18
19
20
21
22
23
163/00
01
350°
6.8 KTS
163/02
03
04
05
270°
7.5 KTS


3
4
5
6
7
8
TWO-WAY TRAVELTIME, IN SECONDS
163/19
20
21
22
23
164/00
01
330°
7.9 KTS
164/02
03
04
05
06
07
090°
8.1 KTS


3
4
5
6
7
No data
164/21
22
23
168/05
06
07
08
09
10
292°
5.4 KTS
No data
168/13
14
15
265°
7.3 KTS

HOURS

PIONEER FRACTURE ZONE

TWO-WAY TRAVELTIME, IN SECONDS

HOURS

273°
8.0 KTS

330°
8.0 KTS

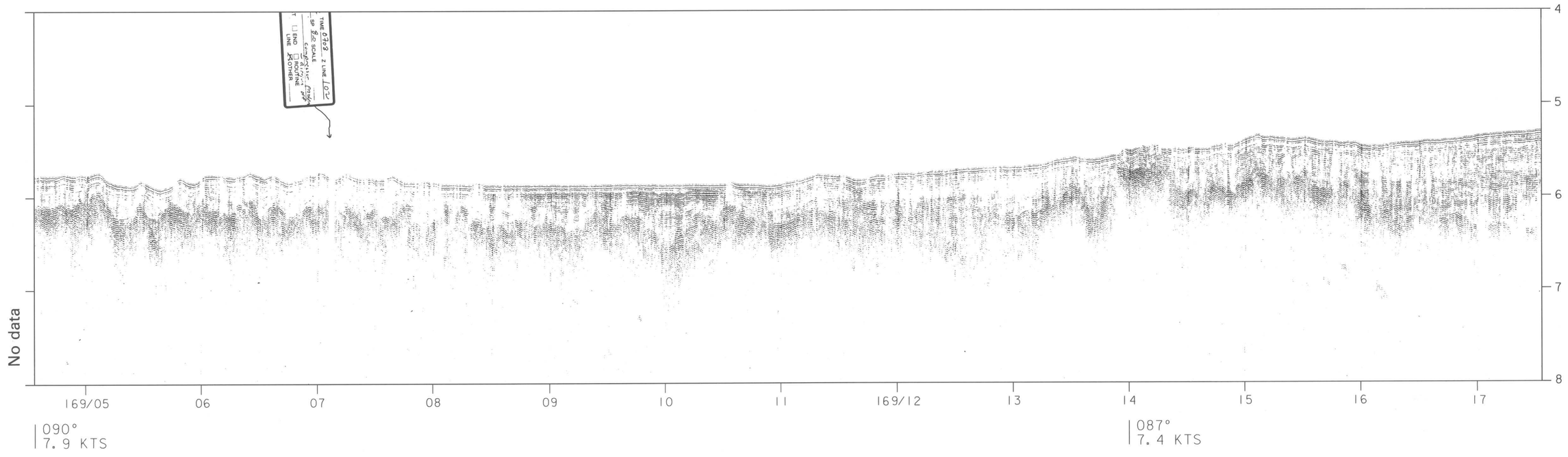
048°
6.5 KTS

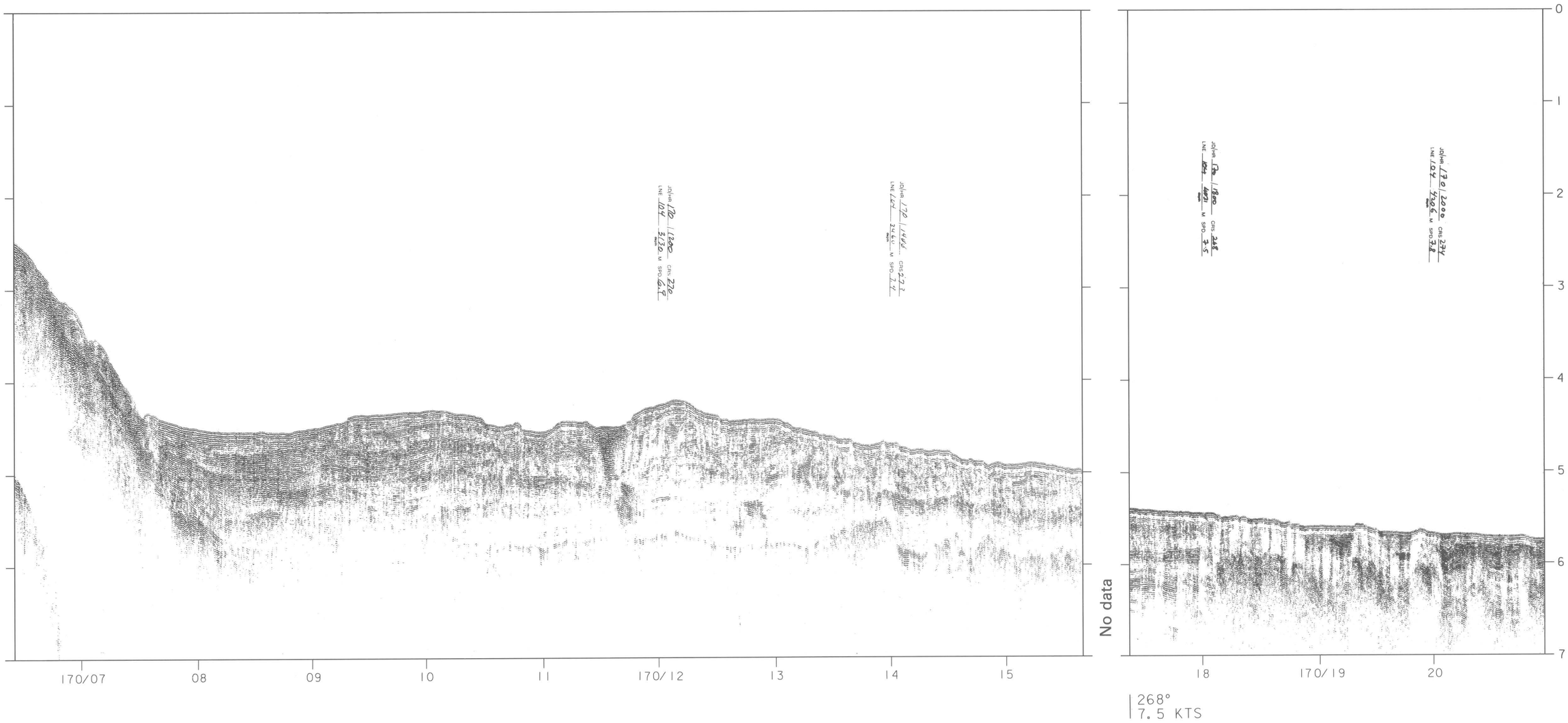
046°
7.5 KTS

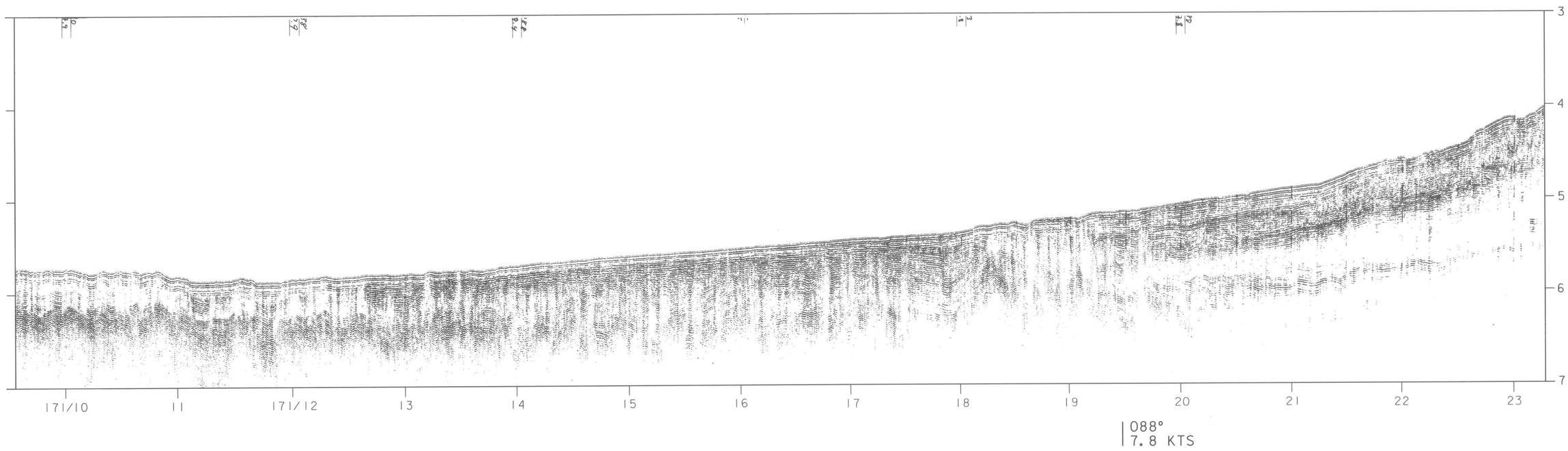
270°
6.4 KTS

336°
7.8 KTS

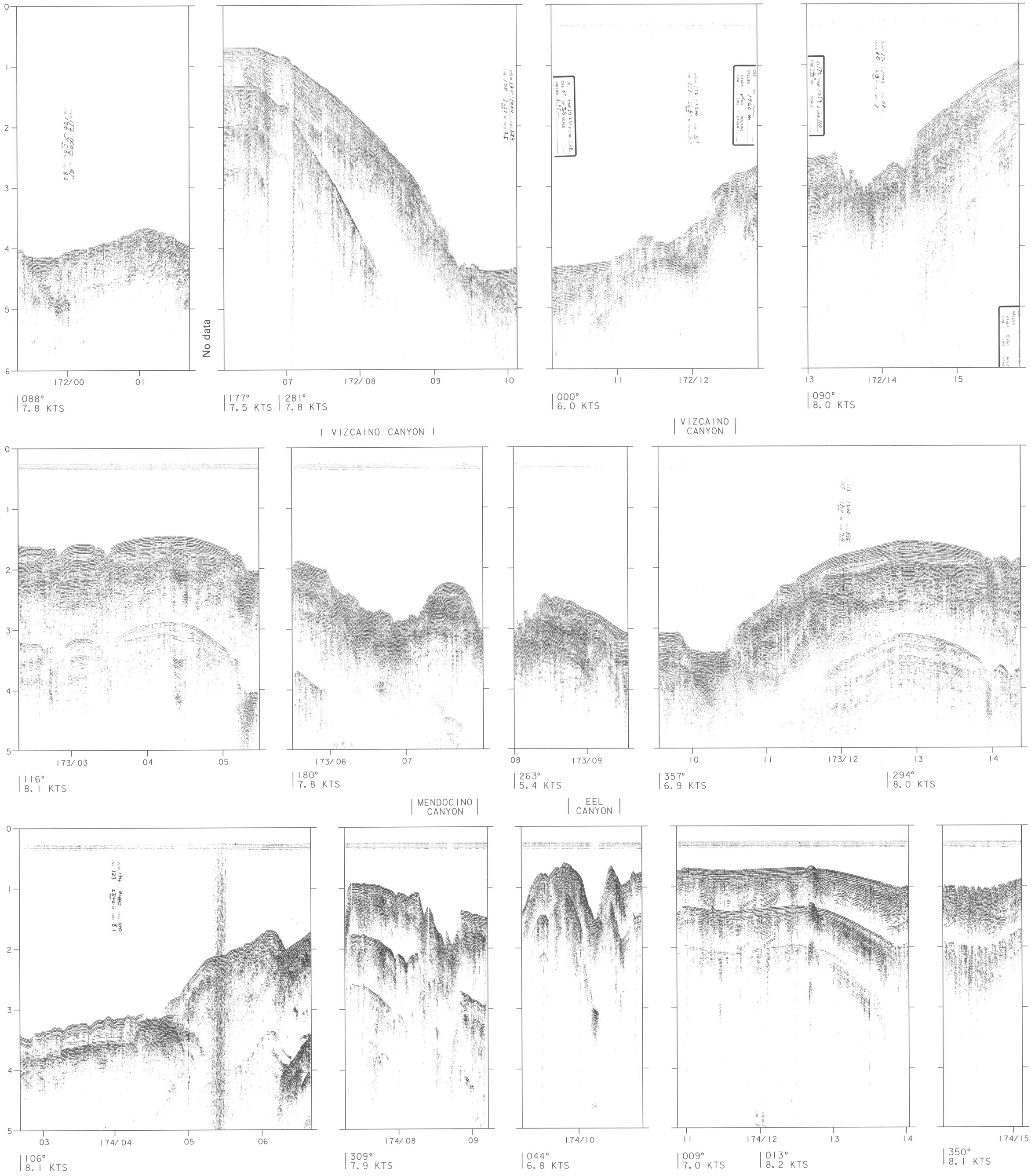
090°
7.7 KTS


No data
169/05
06
07
08
09
10
11
169/12
13
14
15
16
17
090°
7.9 KTS
087°
7.4 KTS
4
5
6
7
8


No data
170/07
08
09
10
11
170/12
13
14
15
18
170/19
20
268°
7.5 KTS
0
1
2
3
4
5
6
7
TWO-WAY TRAVELTIME, IN SECONDS


171/10
11
171/12
13
14
15
16
17
18
19
20
21
22
23
088°
7.8 KTS
3
4
5
6
7

HOURS


TWO-WAY TRAVELTIME, IN SECONDS
0
1
2
3
4
5
6
172/00
01
088°
7.8 KTS
No data
07
172/08
09
10
177°
7.5 KTS
281°
7.8 KTS
11
172/12
000°
6.0 KTS
13
172/14
15
090°
8.0 KTS
I VIZCAINO CANYON I
VIZCAINO CANYON
173/03
04
05
116°
8.1 KTS
173/06
07
180°
7.8 KTS
08
173/09
263°
5.4 KTS
10
11
173/12
13
14
357°
6.9 KTS
294°
8.0 KTS
MENDOCINO CANYON
EEL CANYON
03
174/04
05
06
106°
8.1 KTS
174/08
09
309°
7.9 KTS
174/10
044°
6.8 KTS
11
174/12
13
14
009°
7.0 KTS
013°
8.2 KTS
174/15
350°
8.1 KTS
HOURS

NOYO CANYON

172/16

000°
7.4 KTS

DELGADA CANYON

17

172/18

19

20

330°
7.5 KTS

21

22

23

173/00

298°
7.4 KTS

01

02

180°
7.5 KTS

GORDA ESCARPMENT

15

173/16

17

18

180°
8.0 KTS

173/19

20

264°
6.5 KTS

21

22

23

174/00

01

02

000°
7.5 KTS

TWO-WAY TRAVELTIME, IN SECONDS

0
1
2
3
4
5
6

174/16

17

18

19

20

21

22

23

175/00

01

02

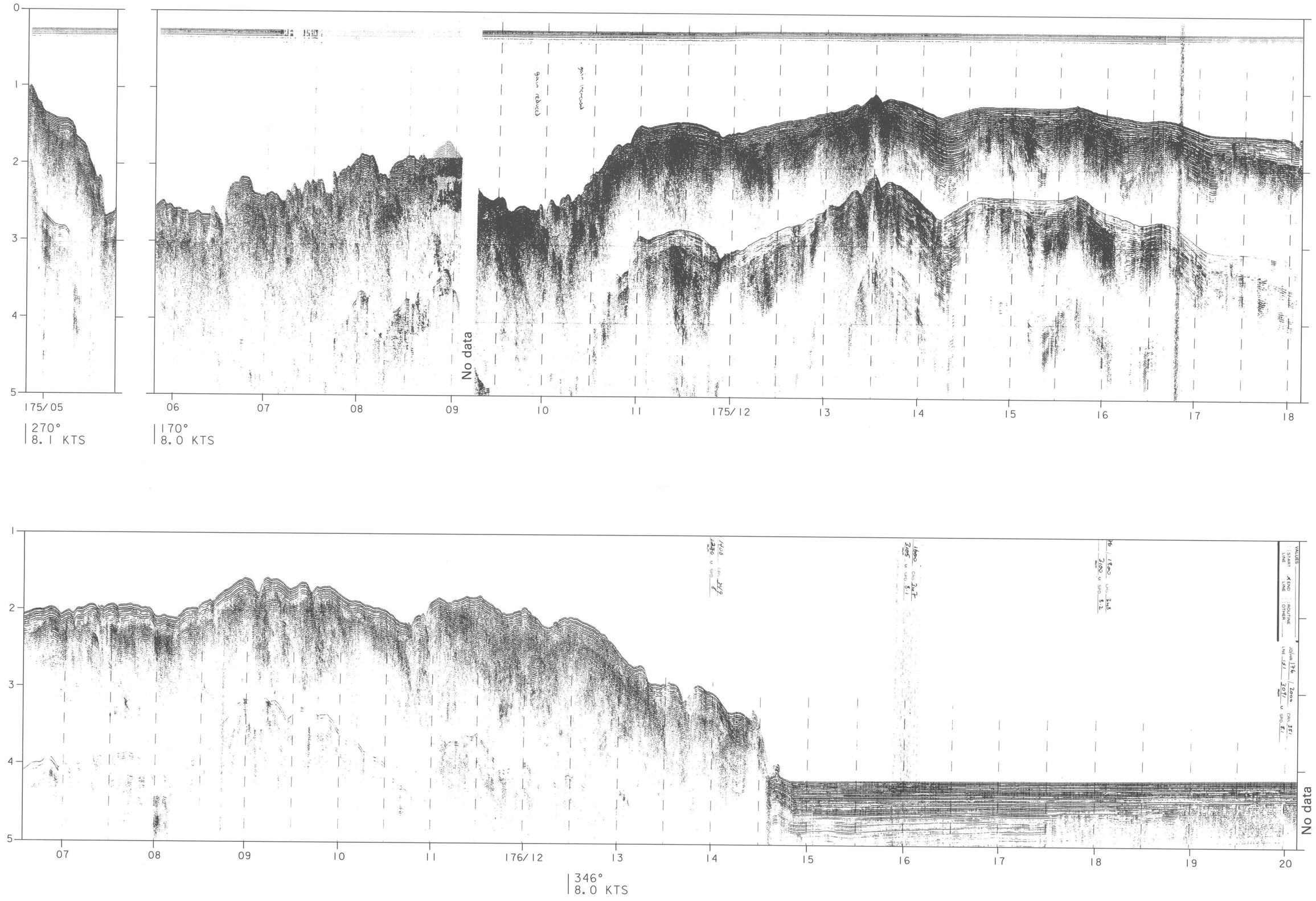
03

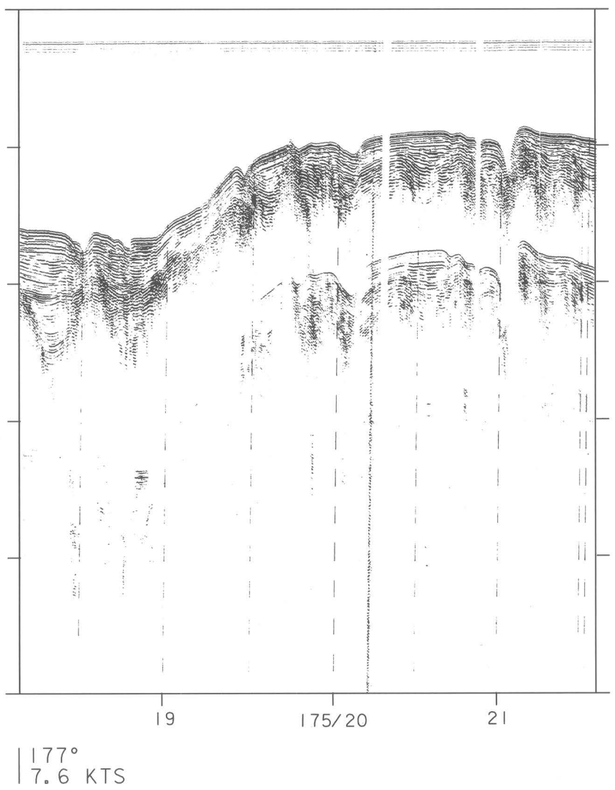
04

351°
8.6 KTS

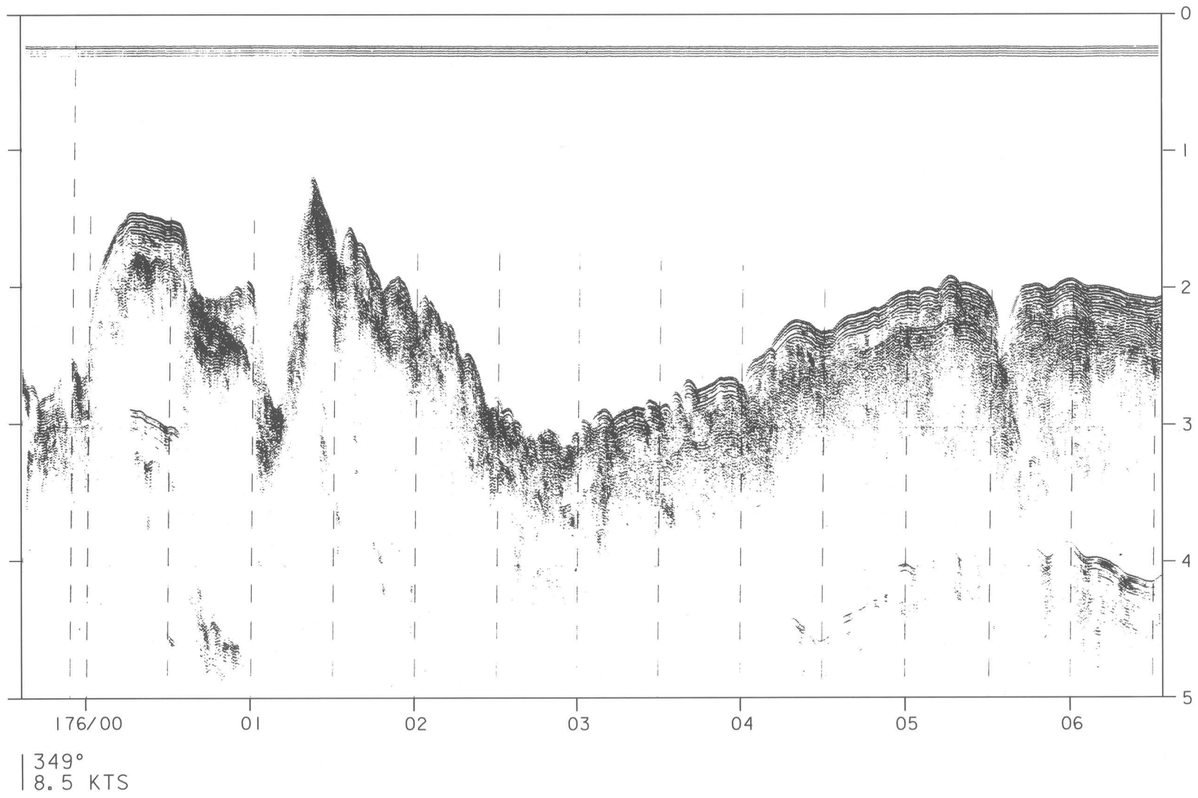
008°
7.1 KTS

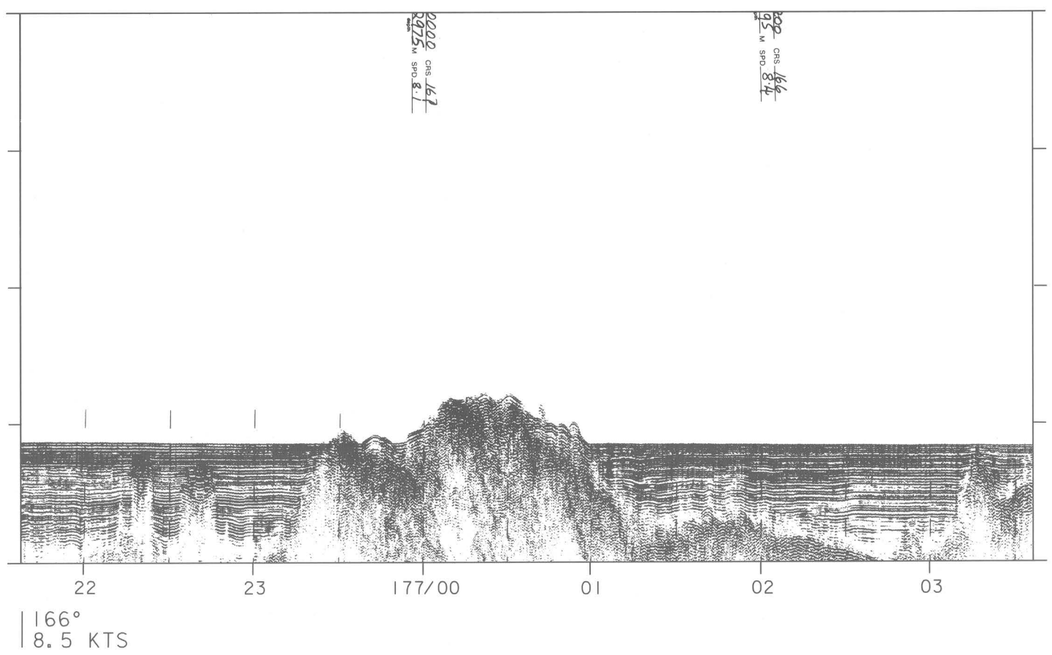
HOURS

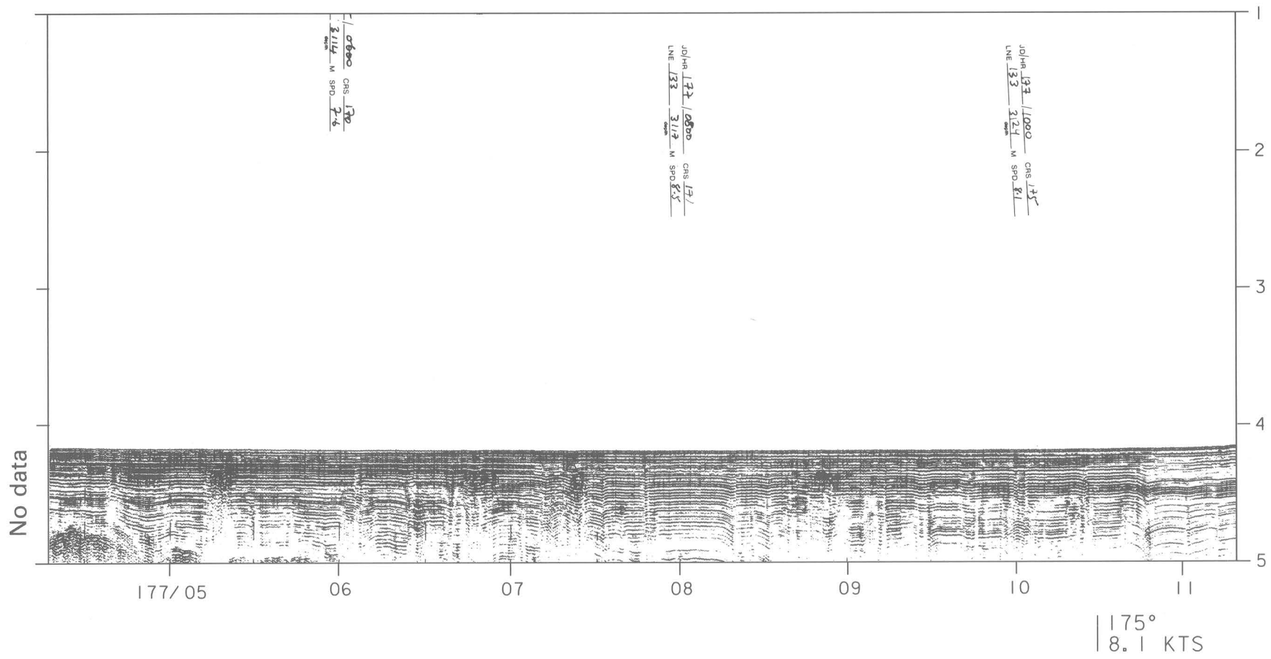

TWO-WAY TRAVELTIME, IN SECONDS
0
1
2
3
4
5
No data
175/05
06
07
08
09
10
11
175/12
13
14
15
16
17
18
270°
8.1 KTS
170°
8.0 KTS
07
08
09
10
11
176/12
13
14
15
16
17
18
19
20
No data
346°
8.0 KTS
GORDA
ESCARPMENT
MENDOCINO RIDGE
1
2
3
4
5
6
7
177/12
13
14
15
177/16
17
18
19
20
21
22
23
178/00
270°
8.0 KTS
180°
8.0 KTS
HOURS



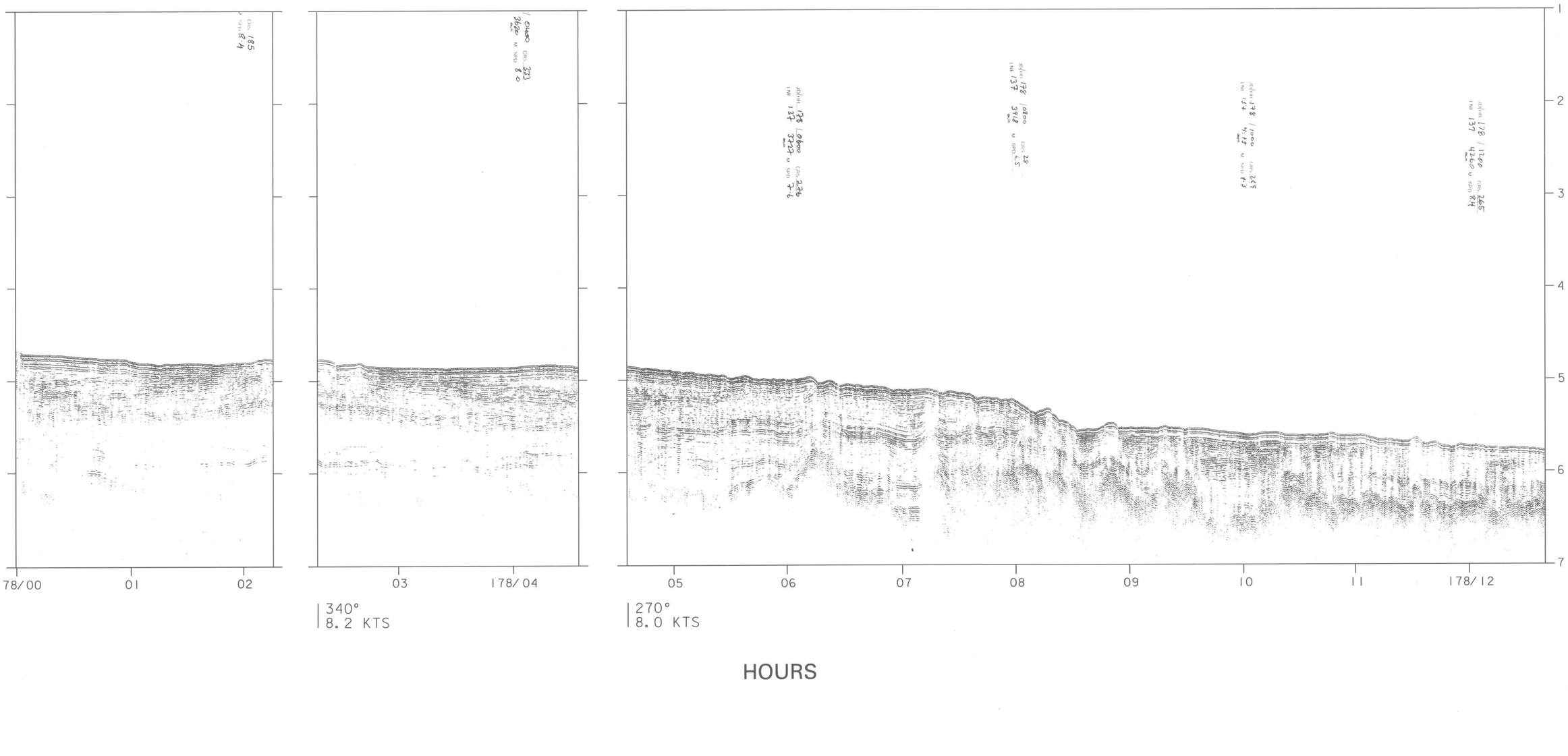




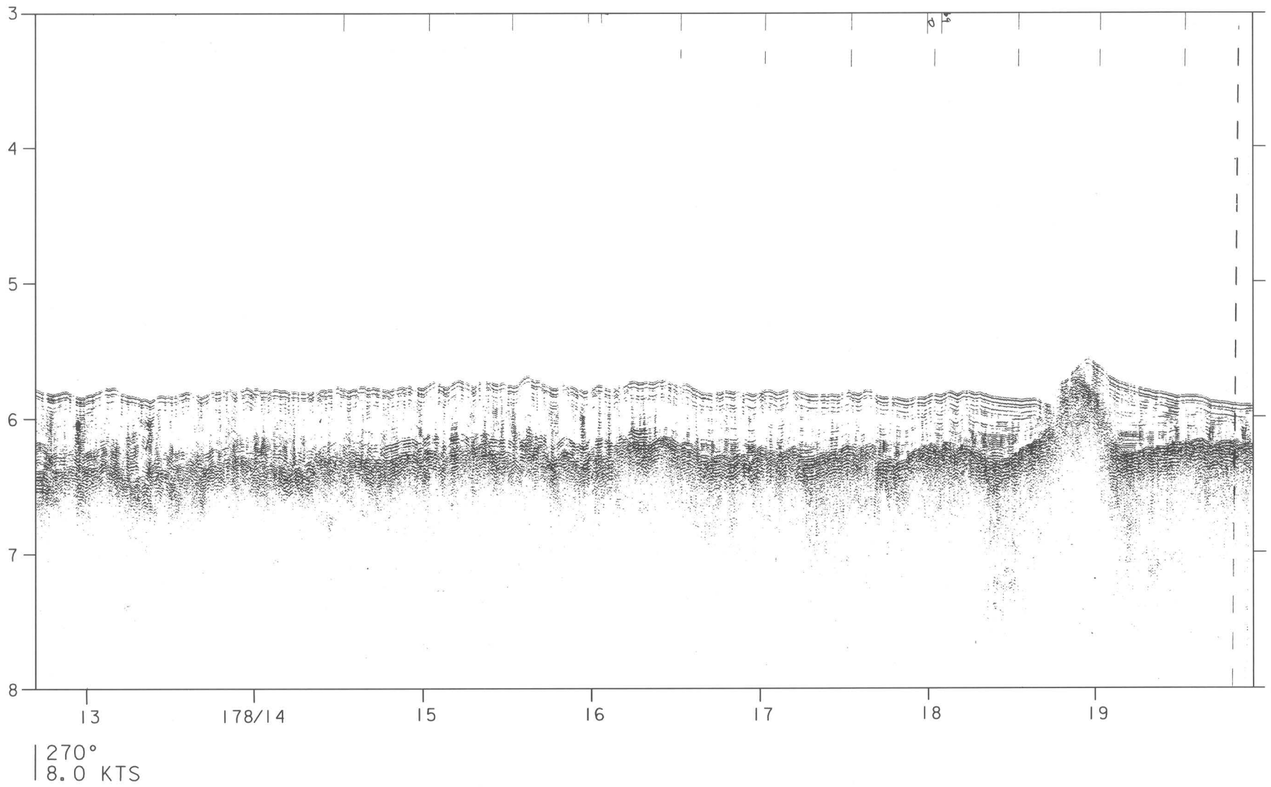


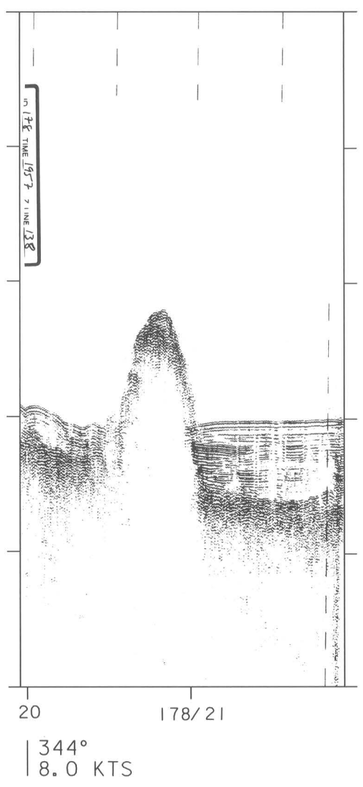


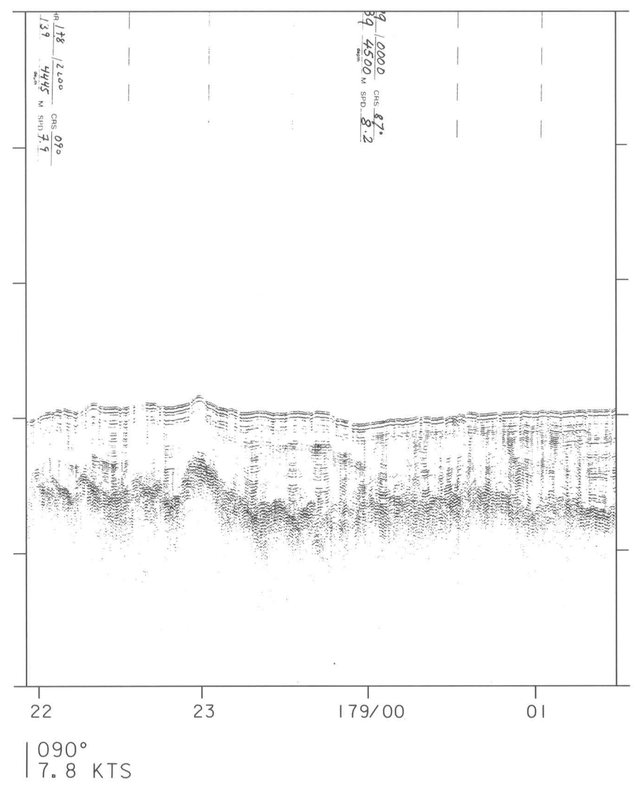
TWO-WAY TRAVELTIME, IN SECONDS

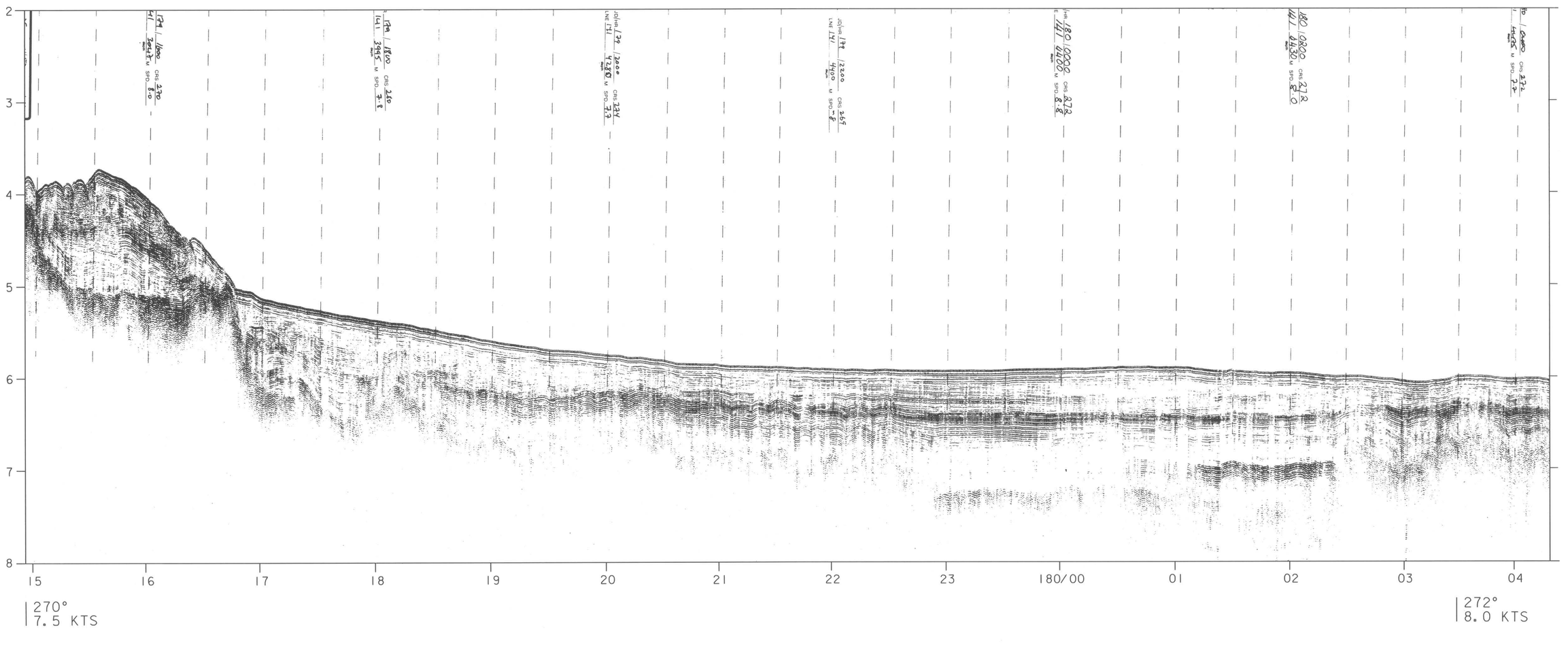


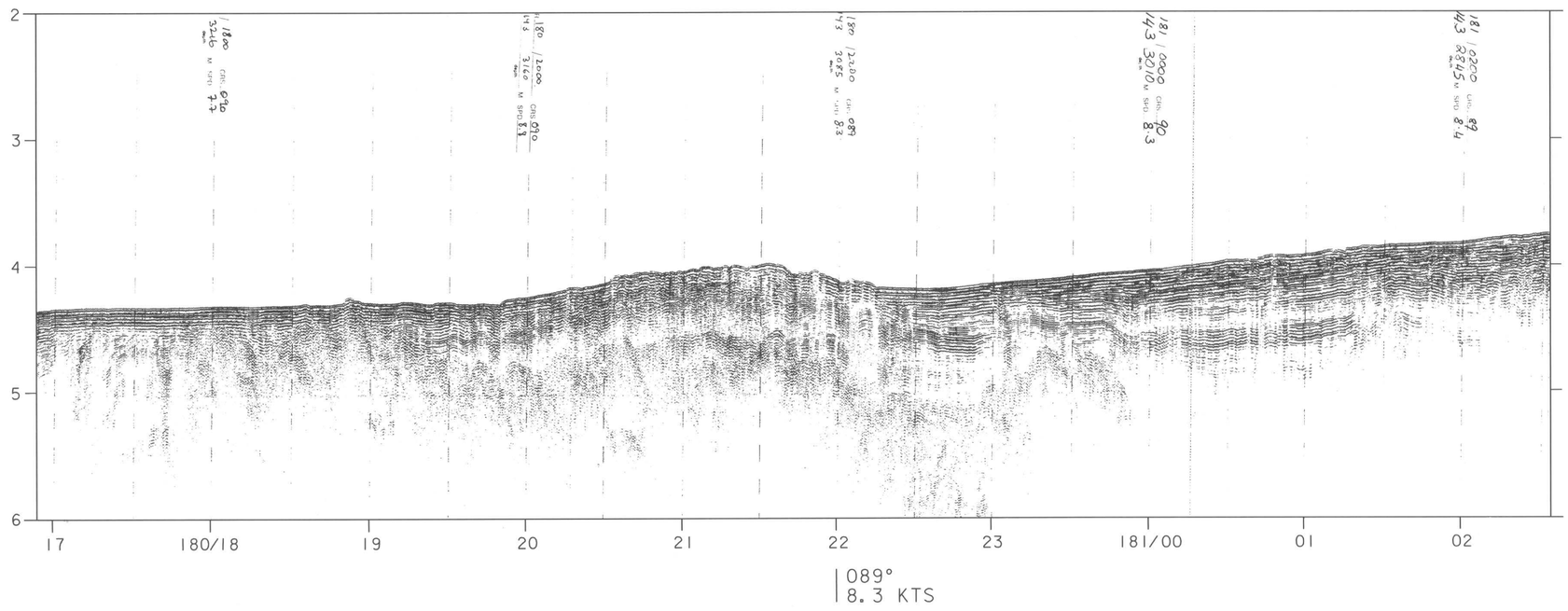
HOURS



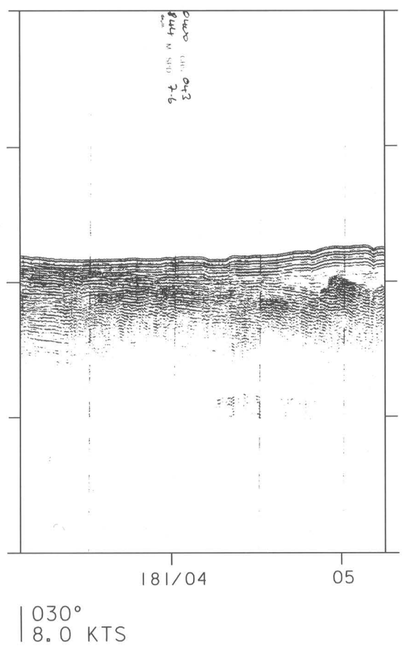




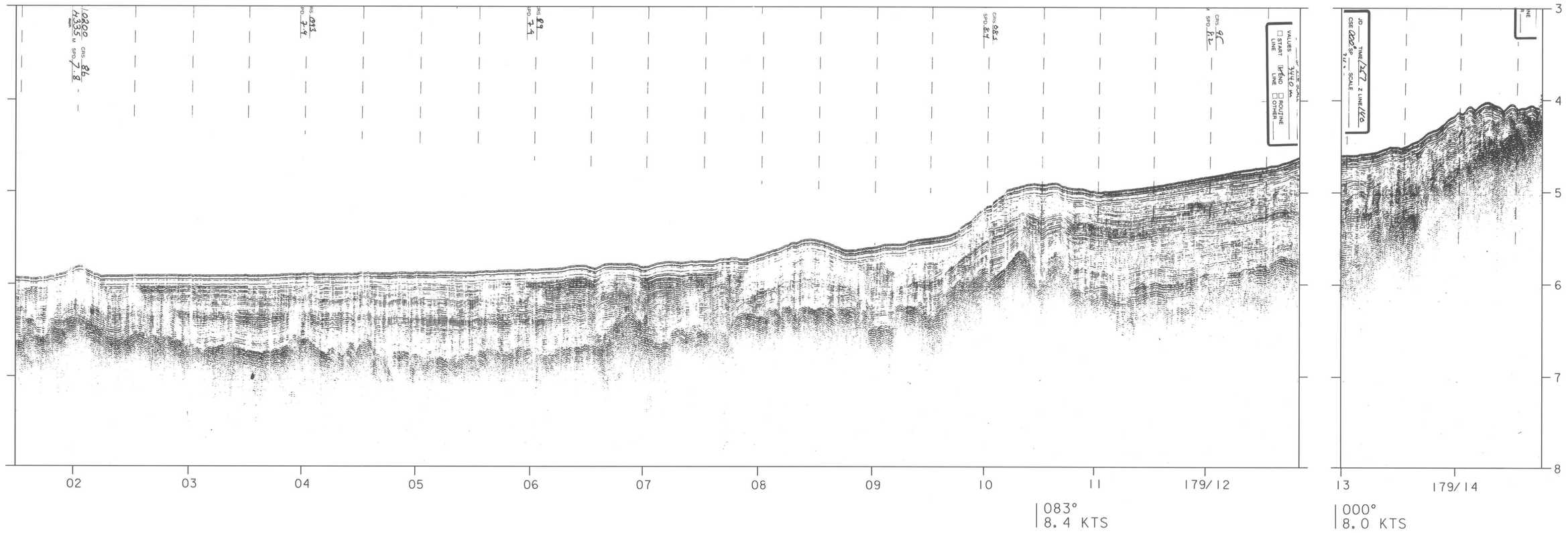


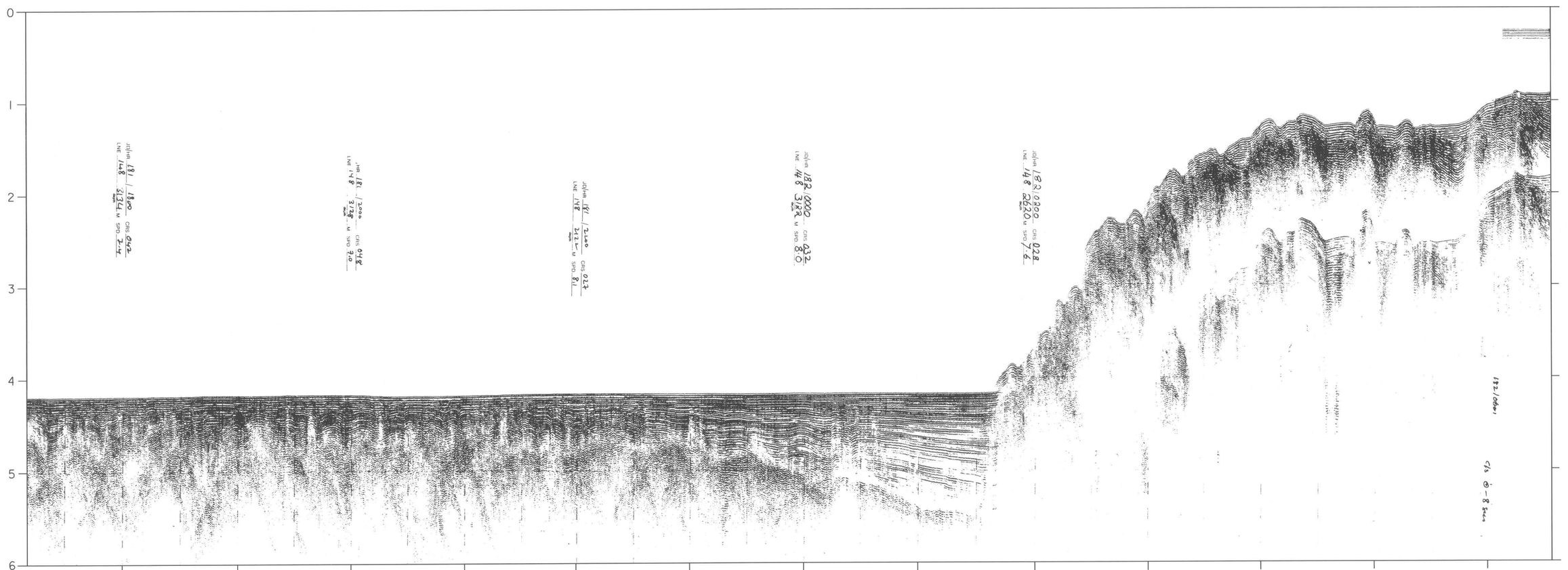


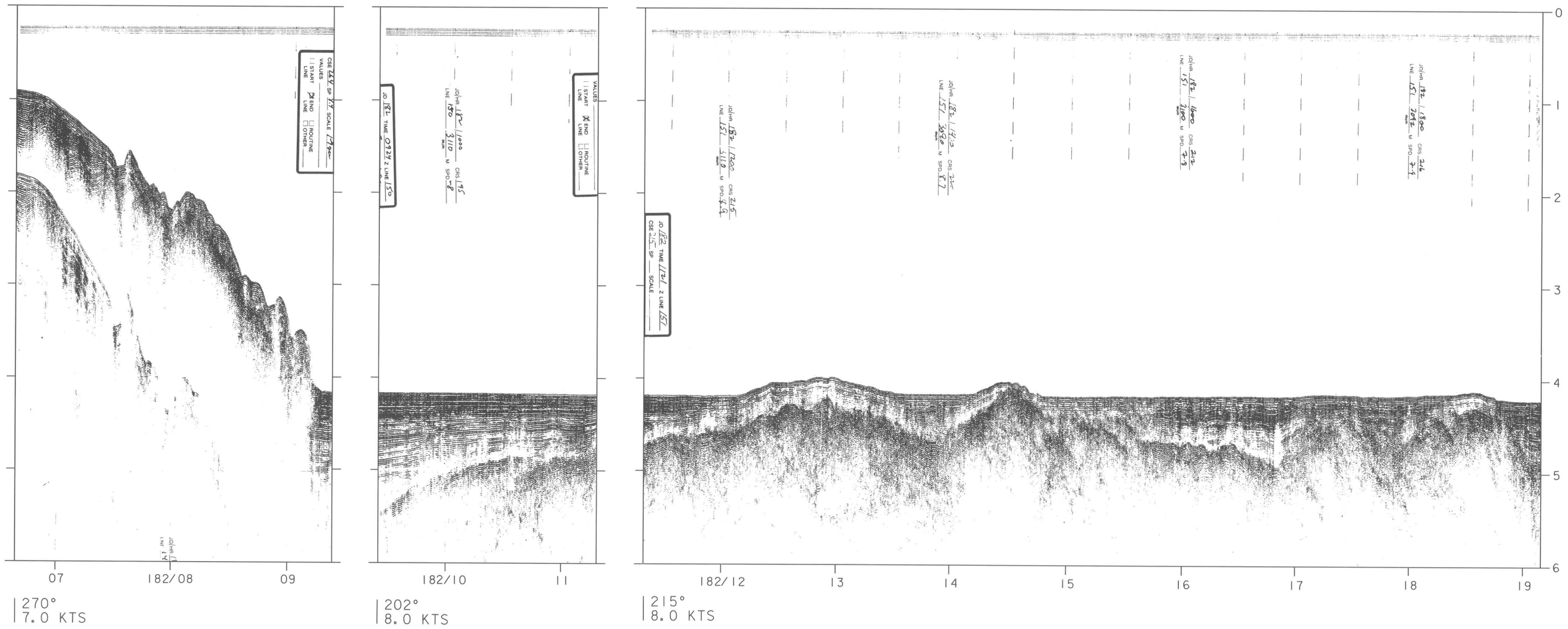
No data



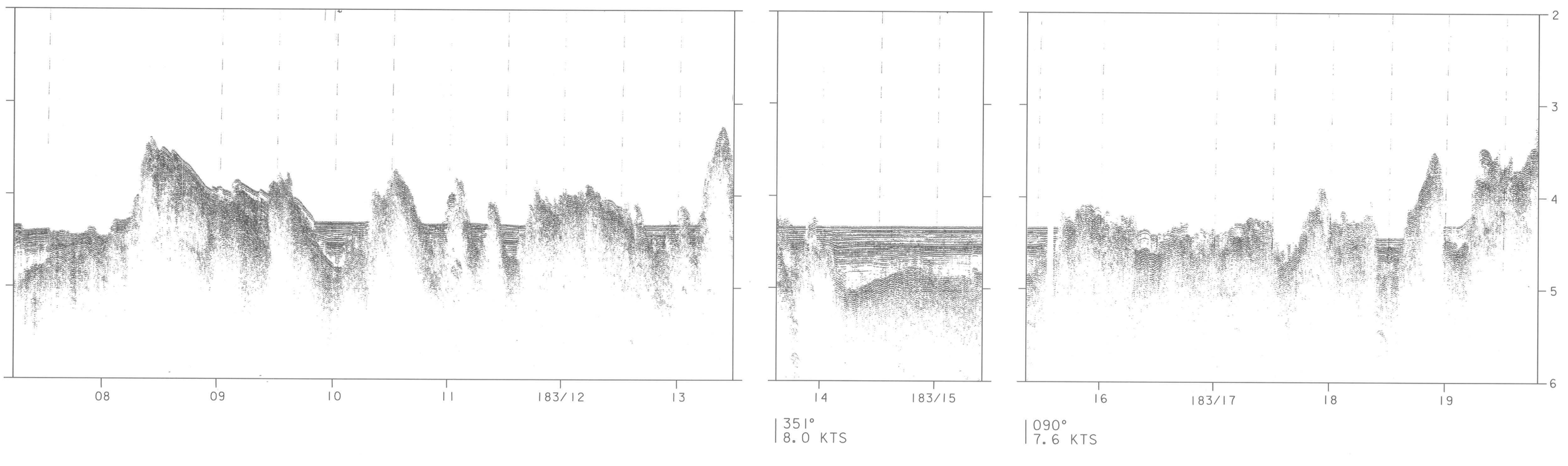
HOURS


02
03
04
05
06
07
08
09
10
11
179/12
083°
8.4 KTS
13
179/14
000°
8.0 KTS
180/ 05
06
07
MENDOCINO RIDGE
180/ 08
09
342°
8.0 KTS
ESCANABA TROUGH
10
11
180/12
13
14
No data
15
16
180°
7.6 KTS
2
3
4
5
6
7
8
TWO-WAY TRAVELTIME, IN SECONDS
06
181/07
08
350°
7.6 KTS
09
10
11
181/12
13
211°
8.7 KTS
14
181/15
270°
7.5 KTS
16
181/17
035°
7.5 KTS
HOURS


TWO-WAY TRAVELTIME, IN SECONDS
0
1
2
3
4
5
6
18
19
20
21
22
23
182/00
01
02
03
04
05
06
042°
7.4 KTS
031°
7.5 KTS
182/20
21
22
23
183/00
01
183/02
03
04
183/05
06
07
273°
7.4 KTS
035°
7.2 KTS
270°
6.6 KTS
ESCANABA TROUGH
20
21
22
23
184/00
01
02
03
04
05
184/06
07
08
083°
8.1 KTS
045°
6.3 KTS
HOURS

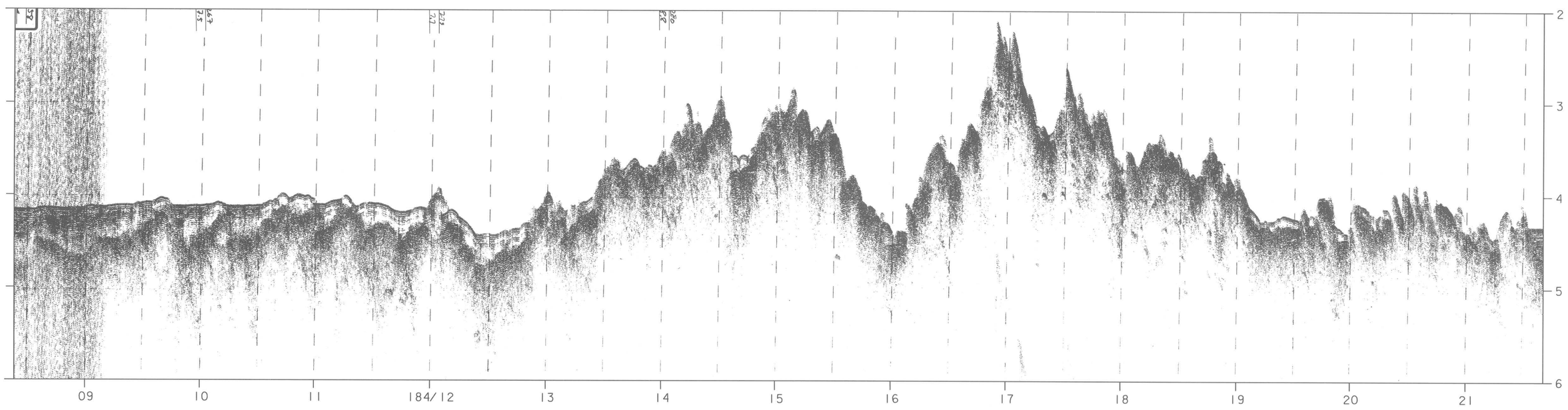


ESCANABA TROUGH

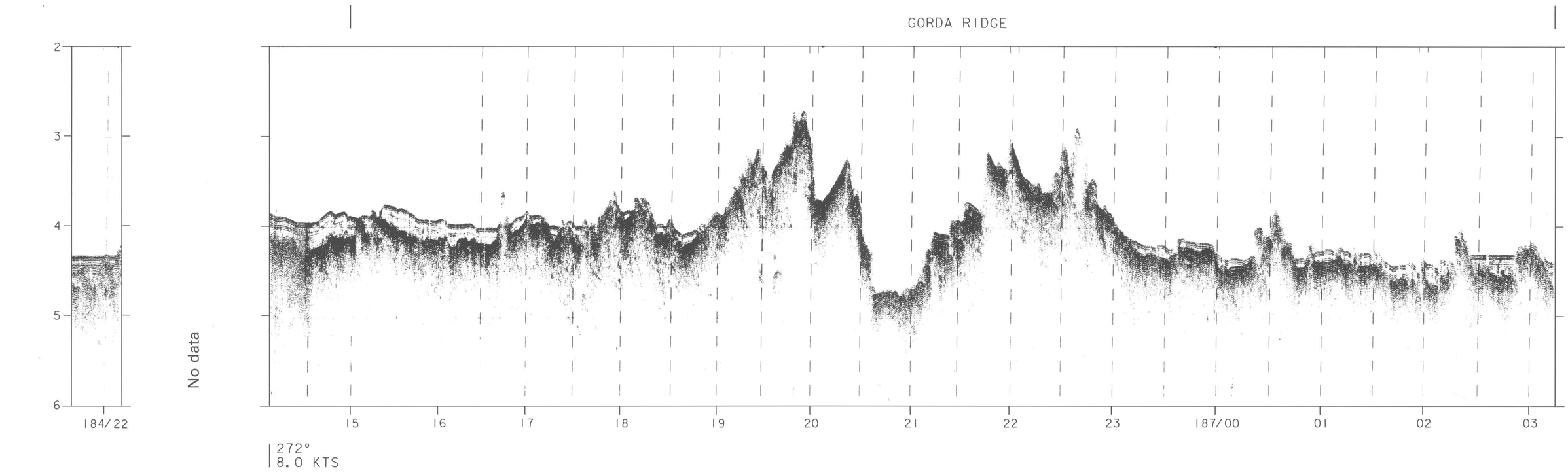


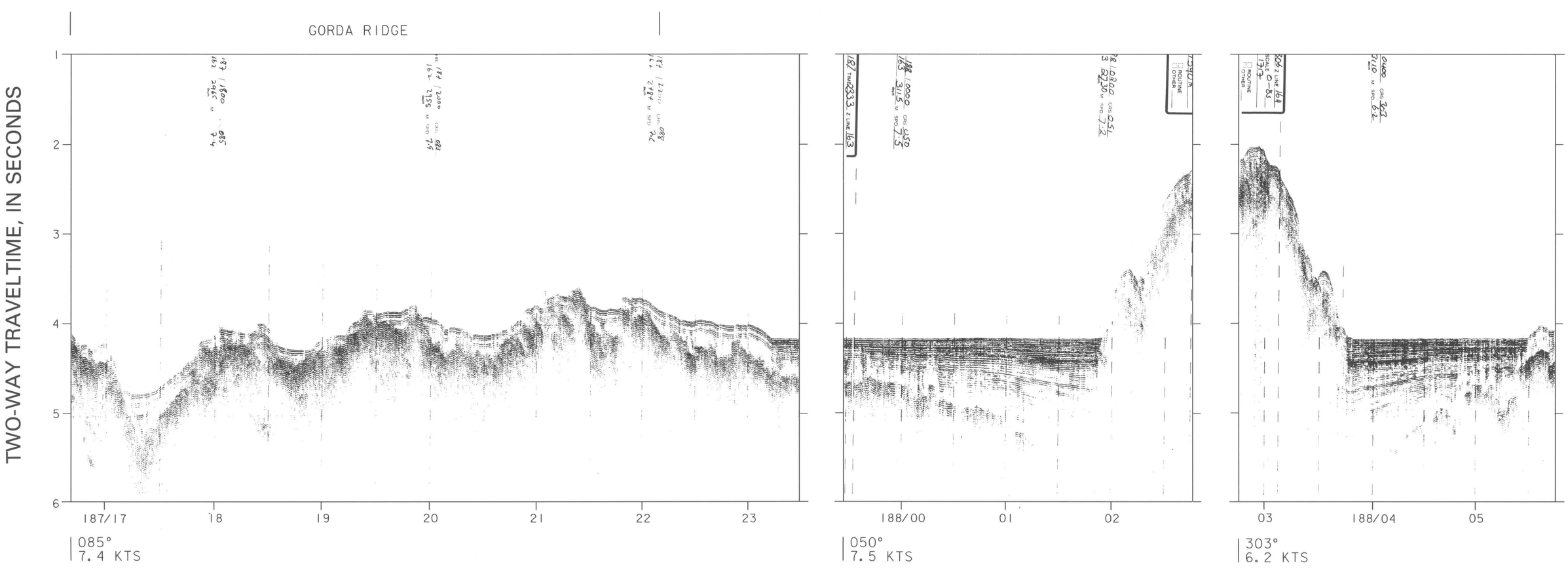
TWO-WAY TRAVELTIME, IN SECONDS

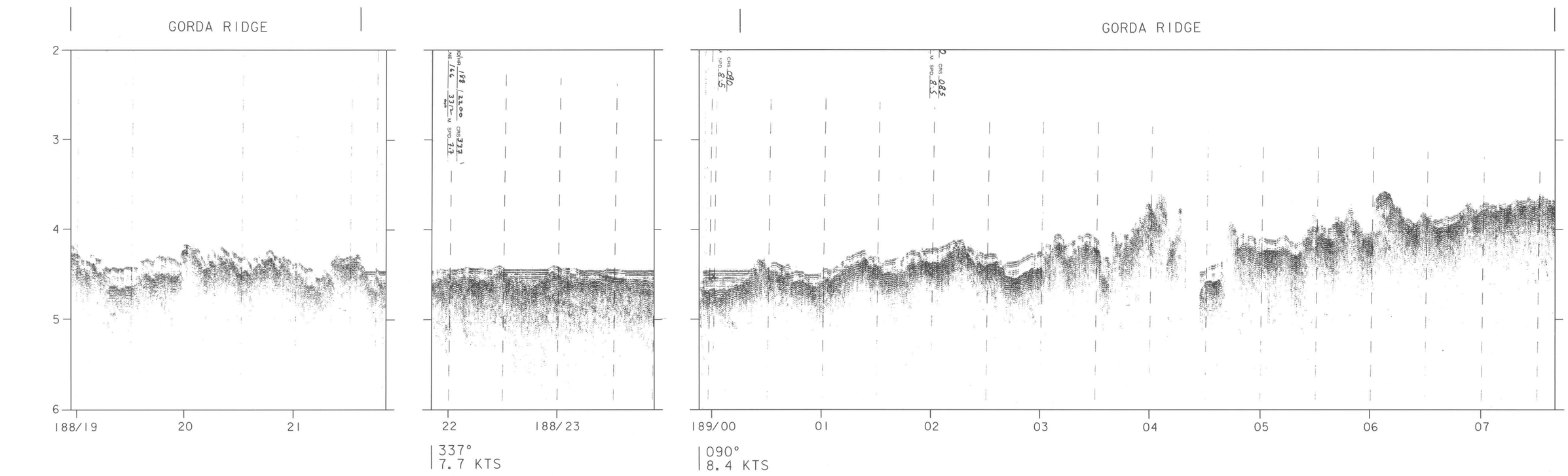
GORDA RIDGE



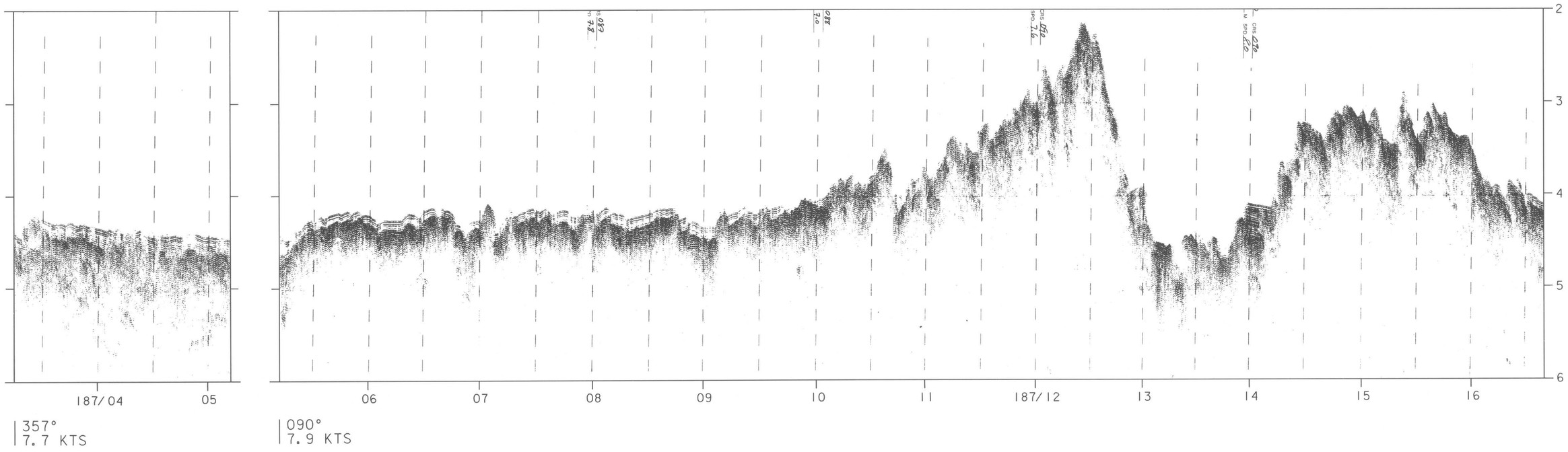
HOURS


GORDA RIDGE
2
3
4
5
6
184/22
No data
15
16
17
18
19
20
21
22
23
187/00
01
02
03
272°
8.0 KTS

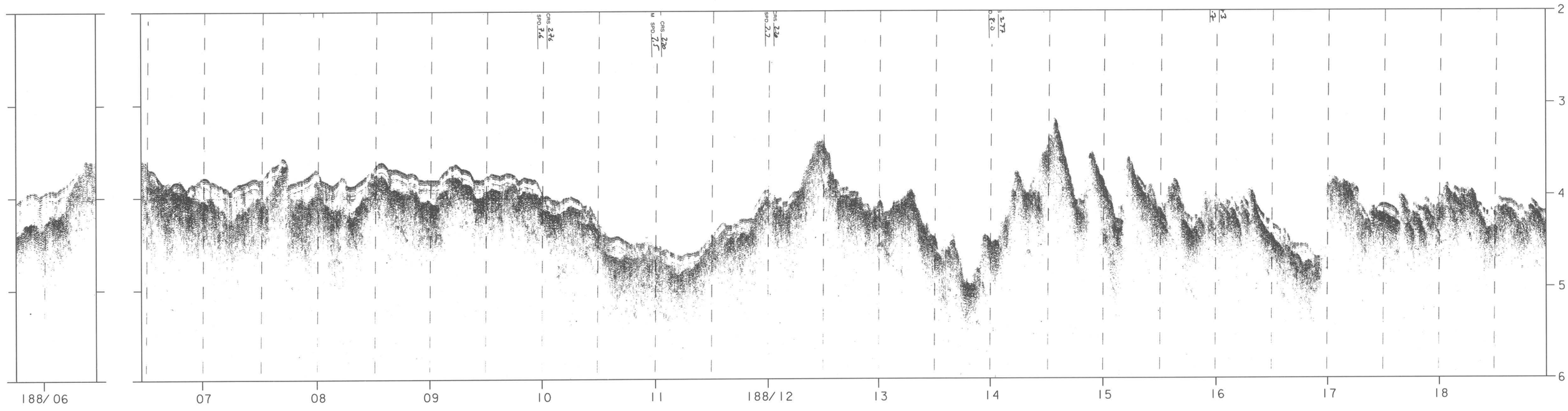

TWO-WAY TRAVELTIME, IN SECONDS
GORDA RIDGE
1
2
3
4
5
6
187/17
18
19
20
21
22
23
085°
7.4 KTS
188/00
01
02
050°
7.5 KTS
03
188/04
05
303°
6.2 KTS


GORDA RIDGE
2
3
4
5
6
188/19
20
21
22
188/23
337°
7.7 KTS
GORDA RIDGE
189/00
01
02
03
04
05
06
07
090°
8.4 KTS
HOURS

GORDA RIDGE

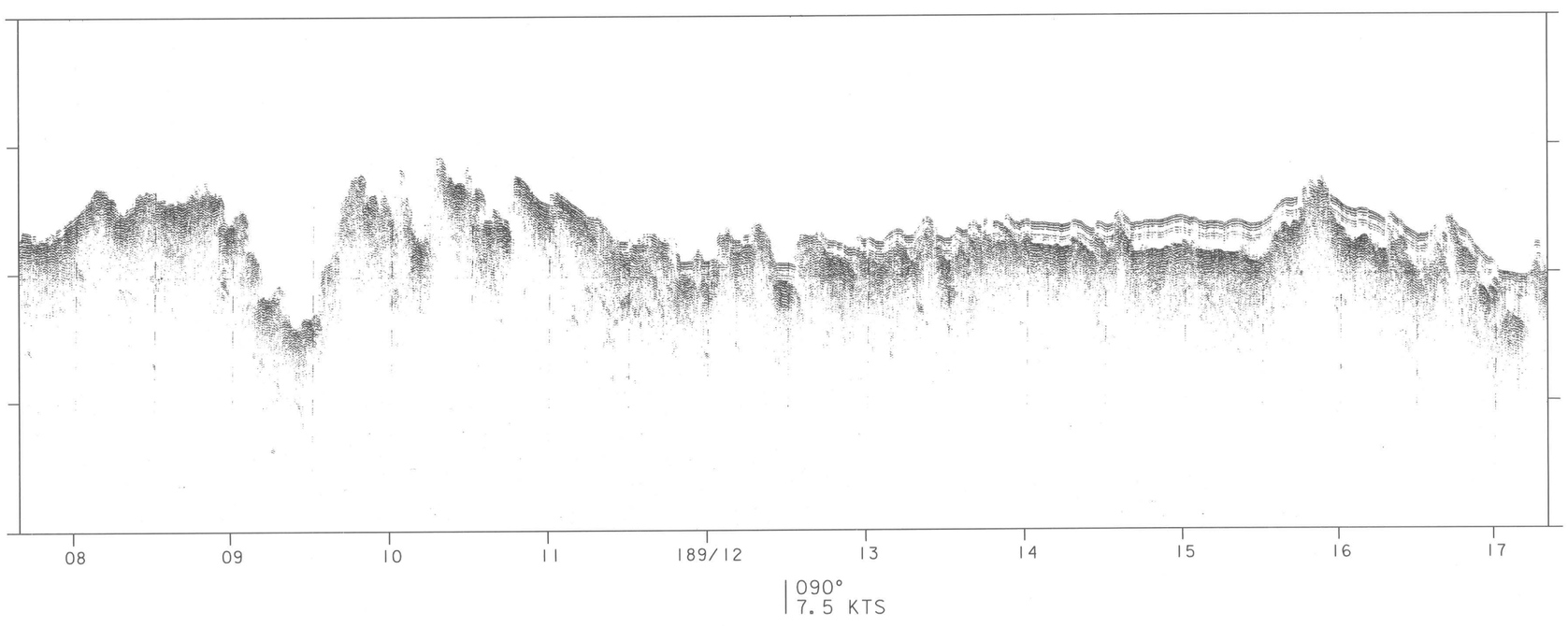


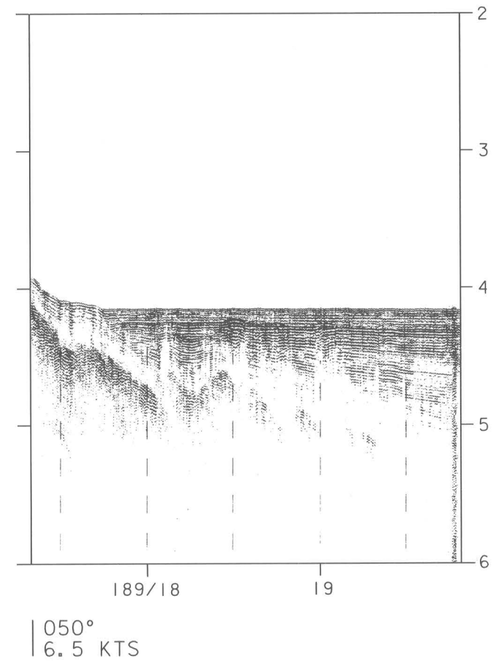
GORDA RIDGE



TWO-WAY TRAVELTIME, IN SECONDS

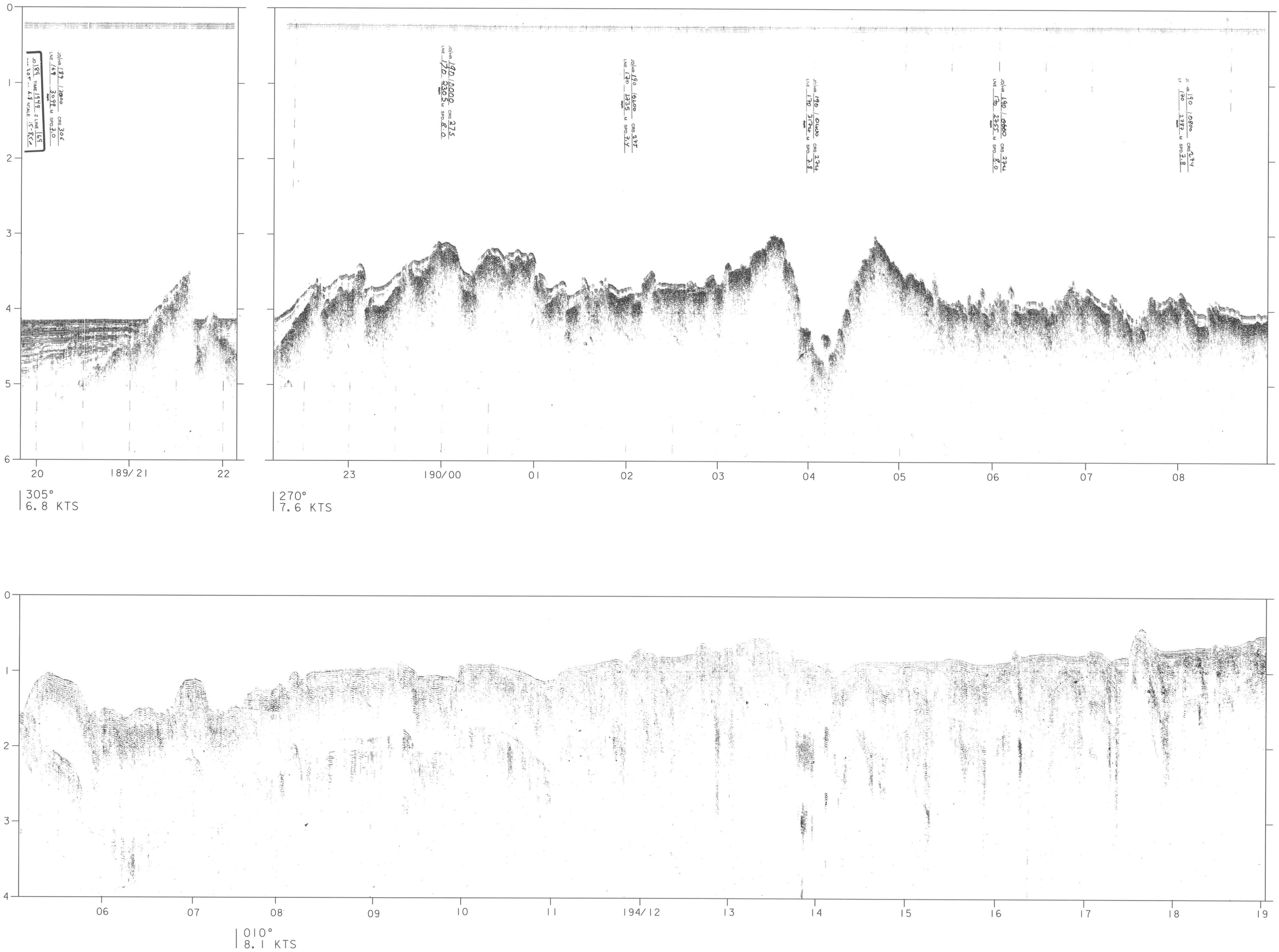
GORDA RIDGE





HOURS

GORDA RIDGE



QUINAULT CANYON

JUAN DE FUCA CANYON

JUAN DE FUCA CANYON

QUINAULT CANYON

HOURS

GORDA RIDGE

PRESIDENT JACKSON SEAMOUNT

No data

09 10 11 190/12 13 14

ASTORIA CANYON | WILLAPA CANYON | GUIDE CANYON | GRAYS CANYON

194/20 21 22 23 195/00 01 02 03 04 05 06 07 08

018° 8.2 KTS | 330° 8.2 KTS | 024° 8.0 KTS

TWO-WAY TRAVELTIME, IN SECONDS

QUINAULT CANYON | NITINAT CANYON | NITINAT CANYON | JUAN DE FUCA CANYON

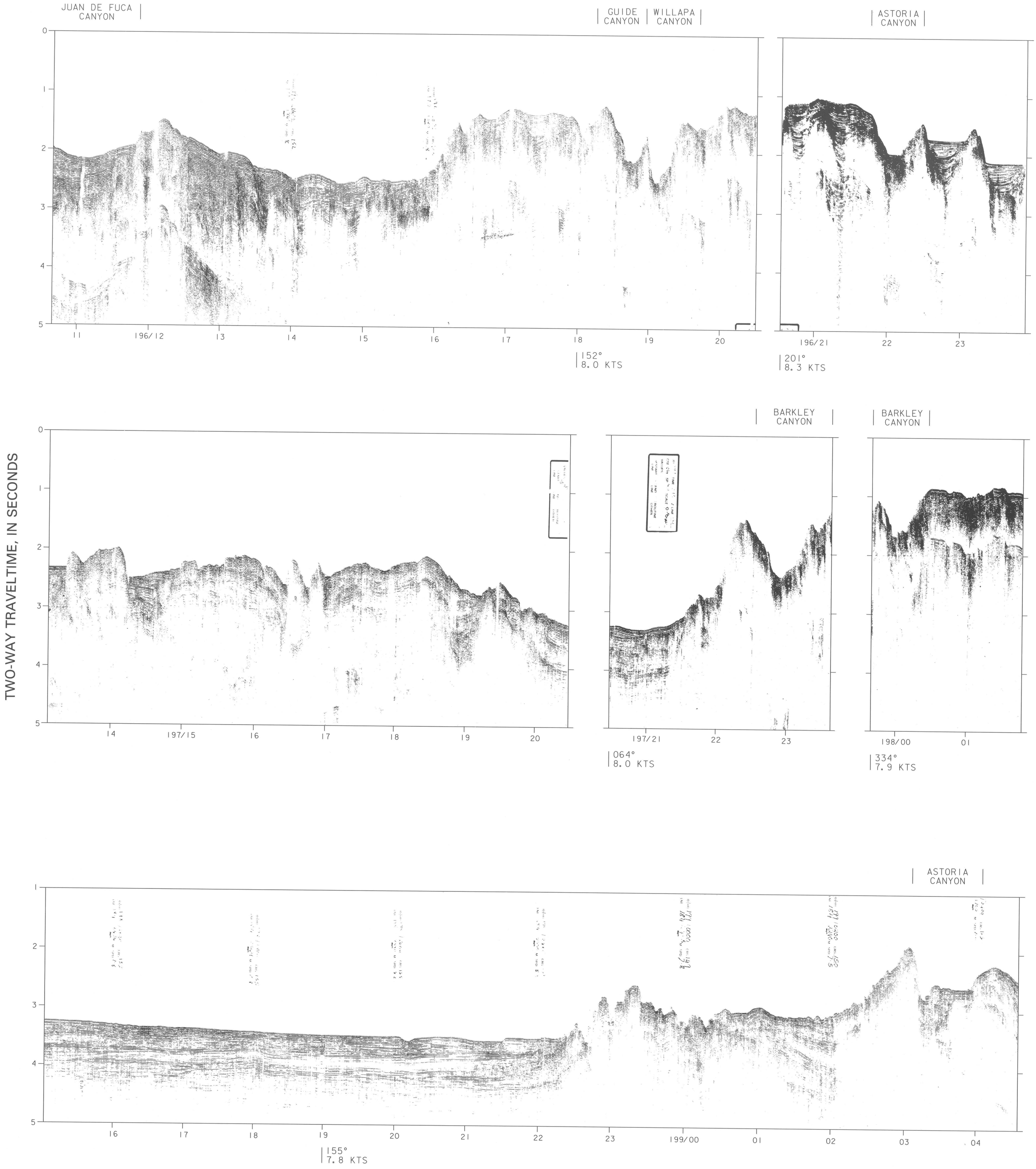
21 22 23 196/00 01 196/02 03 04 05 06 196/07 08 196/10

335° 8.0 KTS | 240° 8.0 KTS | 152° 8.2 KTS

No data

No data

HOURS


JUAN DE FUCA CANYON
GUIDE CANYON
WILLAPA CANYON
ASTORIA CANYON
BARKLEY CANYON
BARKLEY CANYON
ASTORIA CANYON
TWO-WAY TRAVELTIME, IN SECONDS
0
1
2
3
4
5
11
196/12
13
14
15
16
17
18
19
20
152°
8.0 KTS
196/21
22
23
201°
8.3 KTS
14
197/15
16
17
18
19
20
197/21
22
23
064°
8.0 KTS
198/00
01
334°
7.9 KTS
16
17
18
19
20
21
22
23
199/00
01
02
03
04
155°
7.8 KTS
HOURS

ASTORIA CANYON

WILLAPA CANYON

197/00 01 197/02 03 04 05 06 07 08 09 10 11 197/12 13

095° 8.0 KTS

334° 8.3 KTS

02 198/03 04 05 06

244° 8.0 KTS

198/07 08 09 10 11 198/12 13 14 15

334° 8.0 KTS

155° 8.2 KTS

05 06 07 08 09 10 11 199/12 13 14 15 16

190° 8.2 KTS

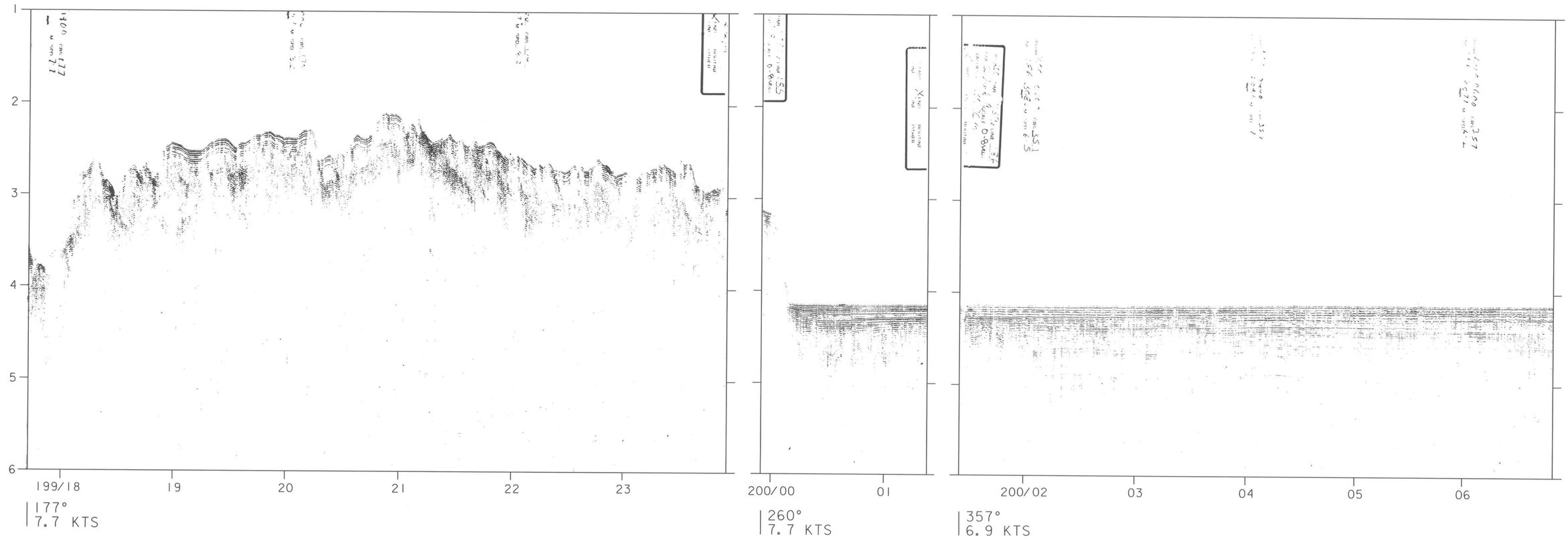
199/17

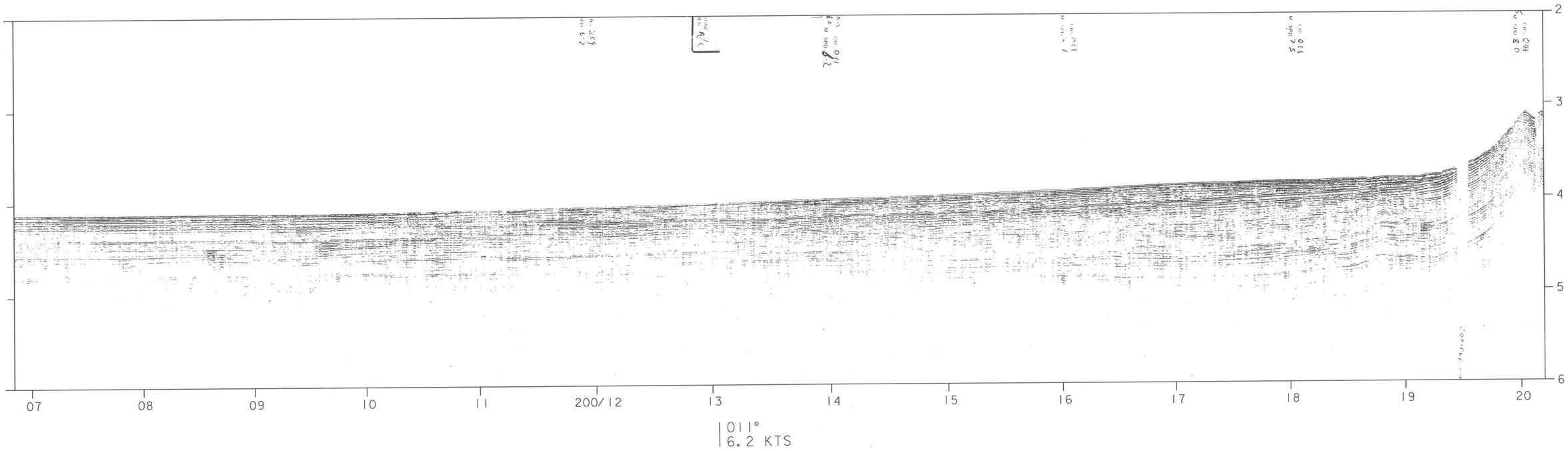
177° 8.0 KTS

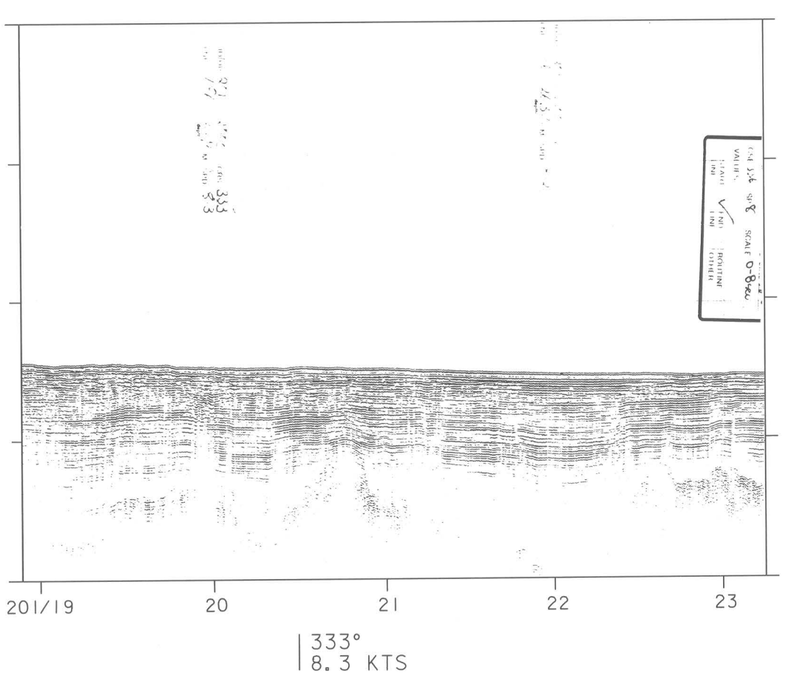
TWO-WAY TRAVELTIME, IN SECONDS

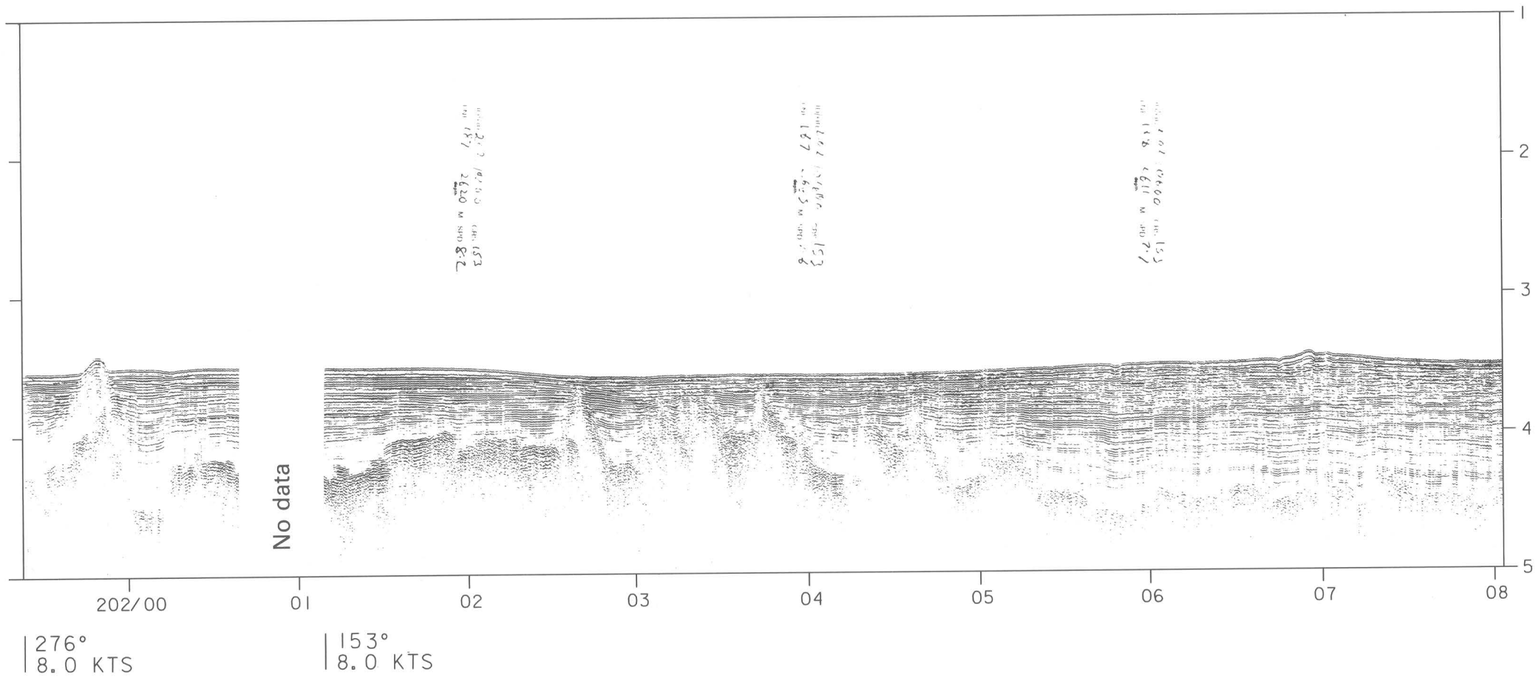
0 1 2 3 4 5

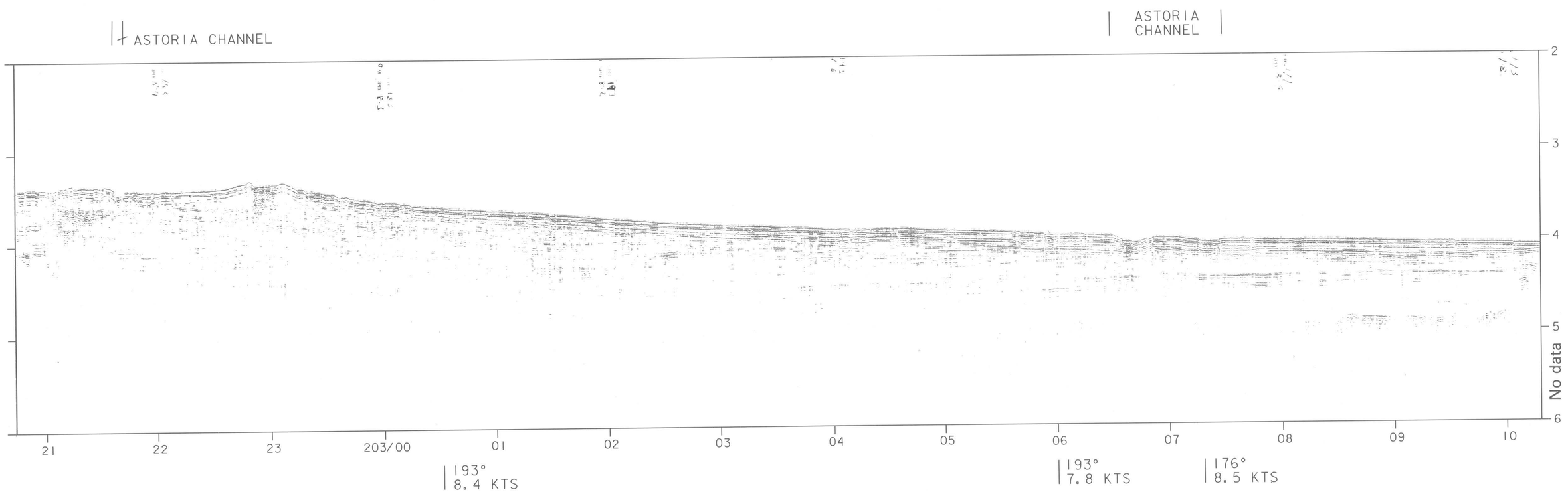
HOURS

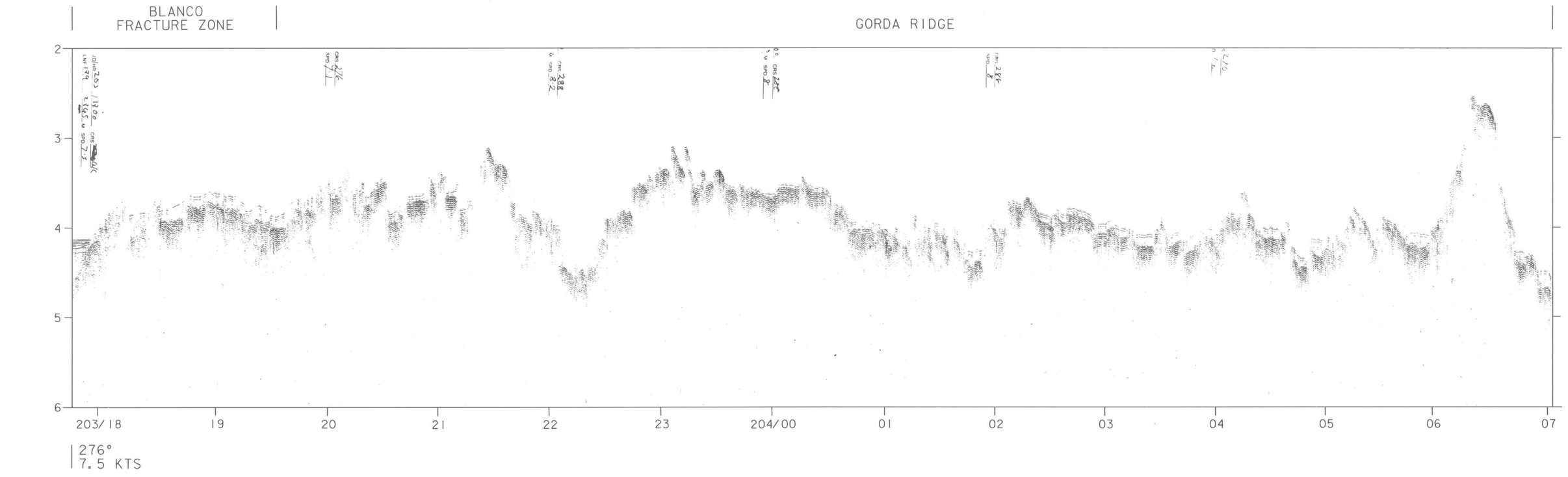

TWO-WAY TRAVELTIME, IN SECONDS
1
2
3
4
5
6
199/18
19
20
21
22
23
177°
7.7 KTS
200/00
01
260°
7.7 KTS
200/02
03
04
05
06
357°
6.9 KTS
200/21
22
014°
8.0 KTS
No data
201/08
09
10
11
201/12
13
14
15
16
17
18
337°
7.8 KTS
CASCADIA SEACHANNEL
WILLAPA CHANNEL
09
10
11
202/12
13
14
15
16
17
18
146°
8.0 KTS
202/19
20
151°
8.1 KTS
HOURS

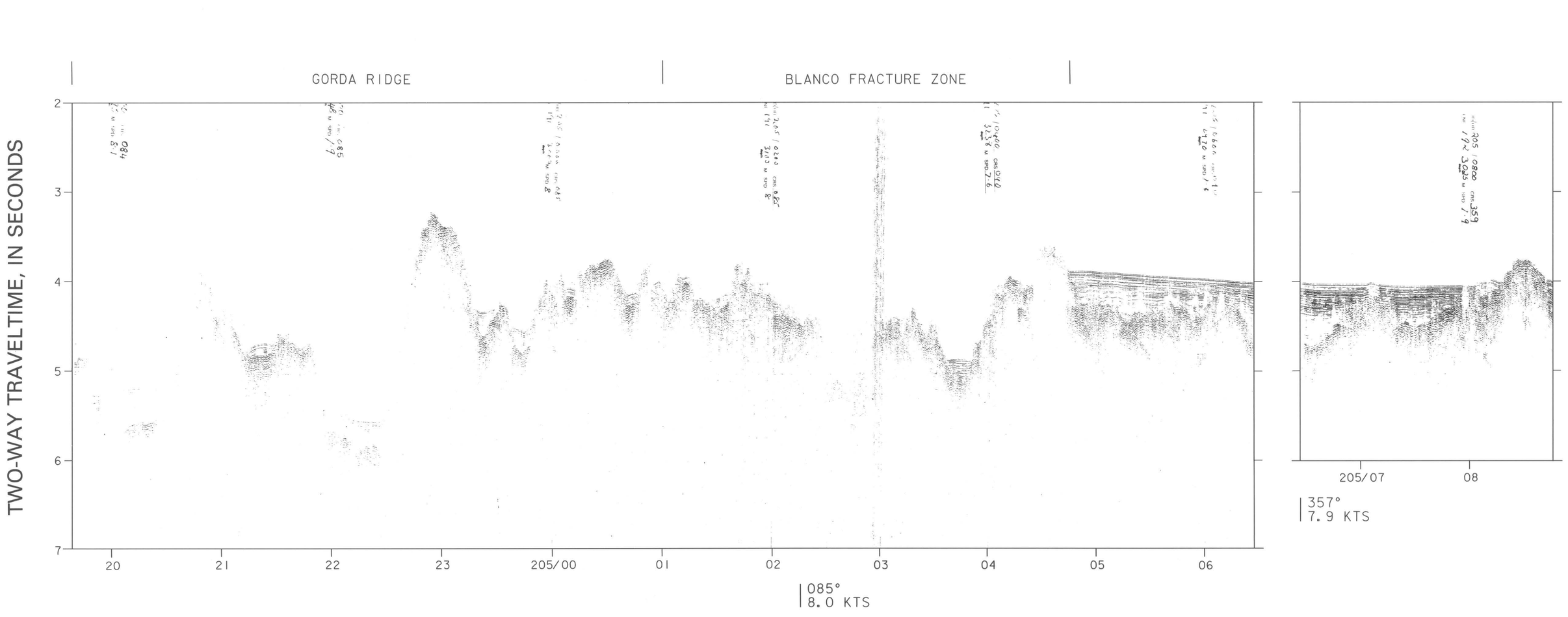

2
3
4
5
6
07
08
09
10
11
200/12
13
14
15
16
17
18
19
20
011°
6.2 KTS


201/19
20
21
22
23
333°
8.3 KTS


1
2
3
4
5
202/00
01
02
03
04
05
06
07
08
No data
276°
8.0 KTS
153°
8.0 KTS
TWO-WAY TRAVELTIME, IN SECONDS

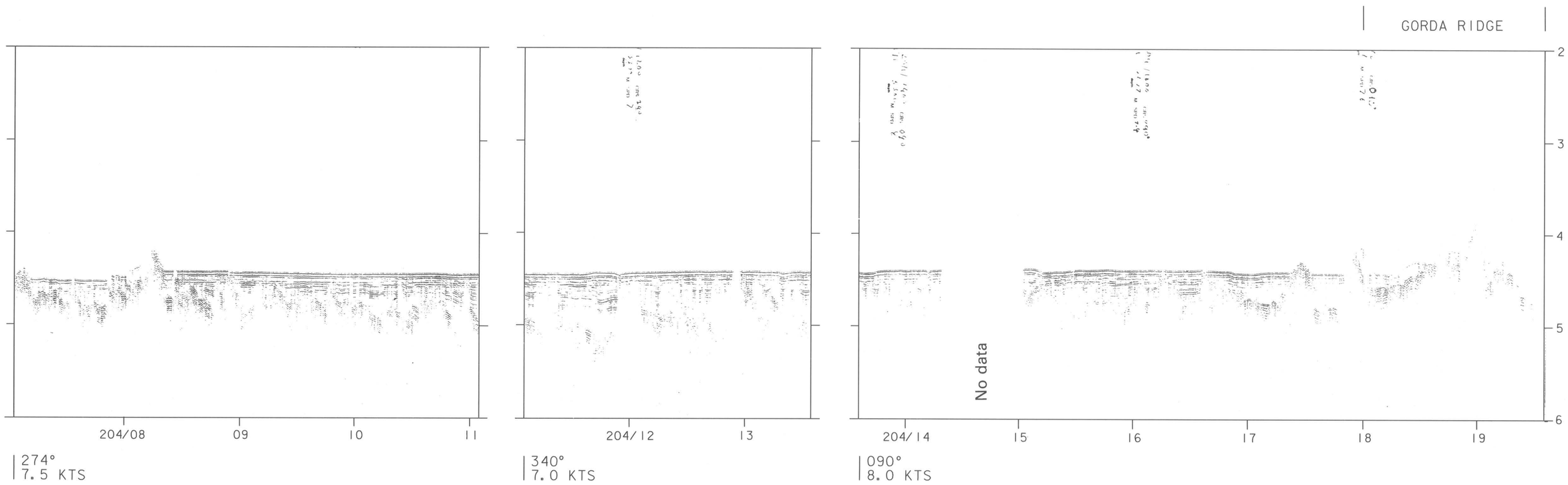

ASTORIA CHANNEL
ASTORIA CHANNEL
2
3
4
5
6
No data
21
22
23
203/00
01
02
03
04
05
06
07
08
09
10
193°
8.4 KTS
193°
7.8 KTS
176°
8.5 KTS
HOURS

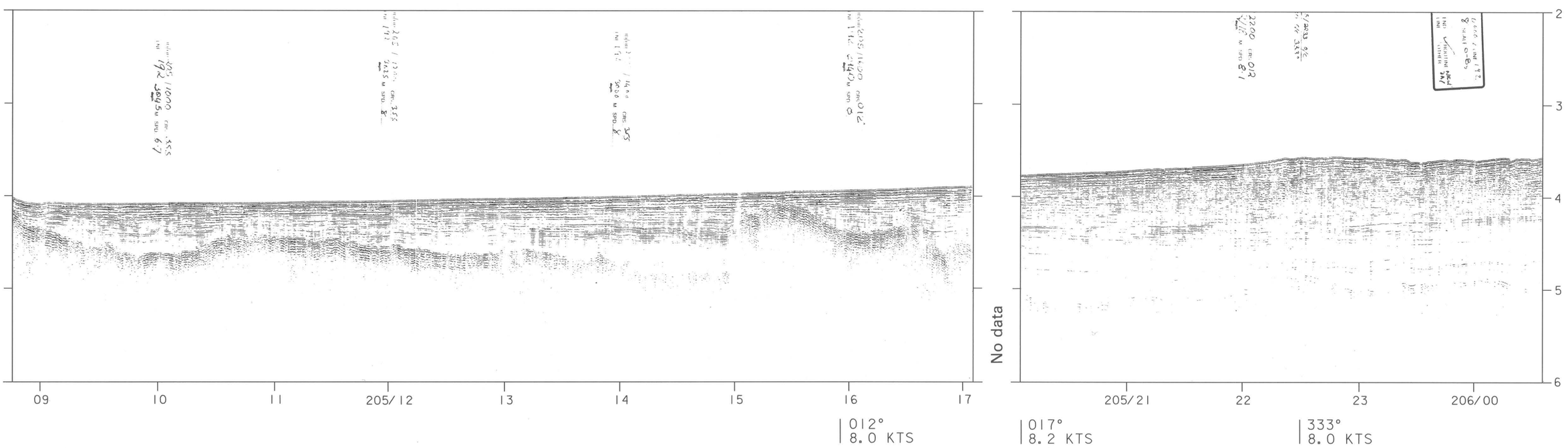

BLANCO FRACTURE ZONE
GORDA RIDGE
2
3
4
5
6
203/18
19
20
21
22
23
204/00
01
02
03
04
05
06
07
276°
7.5 KTS

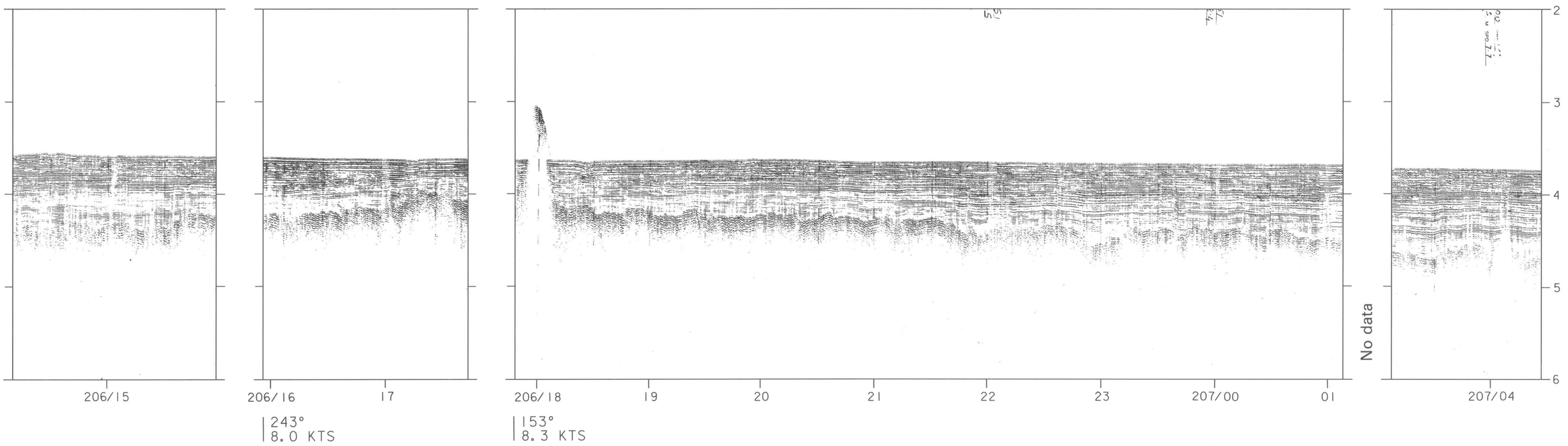

GORDA RIDGE
BLANCO FRACTURE ZONE
TWO-WAY TRAVELTIME, IN SECONDS
2
3
4
5
6
7
20
21
22
23
205/00
01
02
03
04
05
06
085°
8.0 KTS
205/07
08
357°
7.9 KTS

CASCADIA SEACHANNEL
2
3
4
5
6
206/01
02
03
04
05
06
07
08
09
10
11
206/12
13
14
335°
8.2 KTS

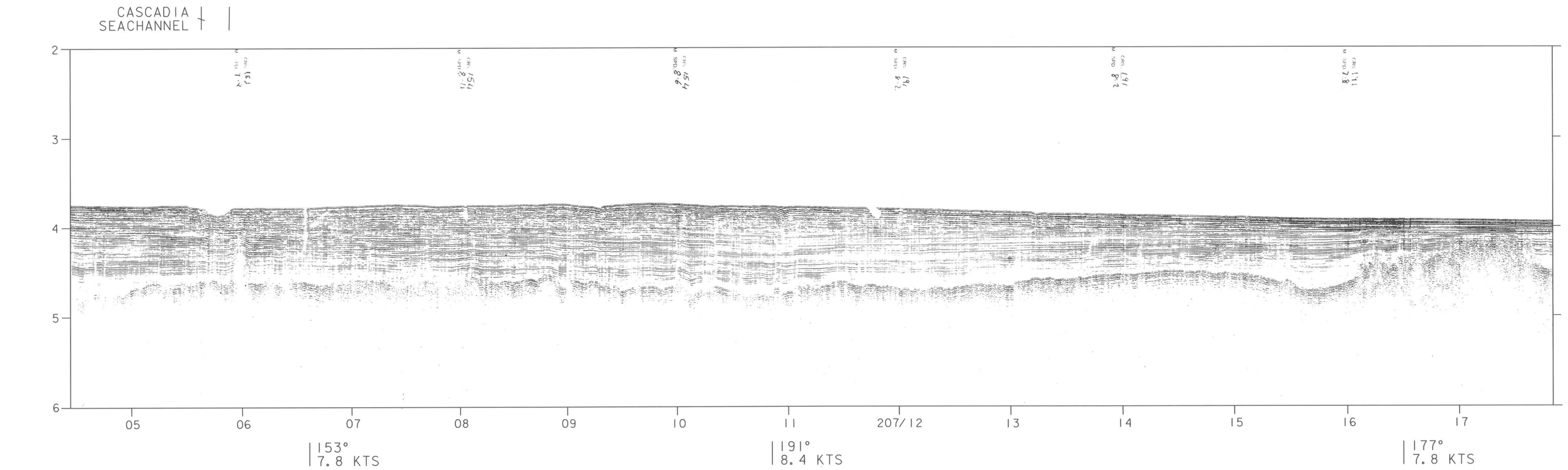
HOURS

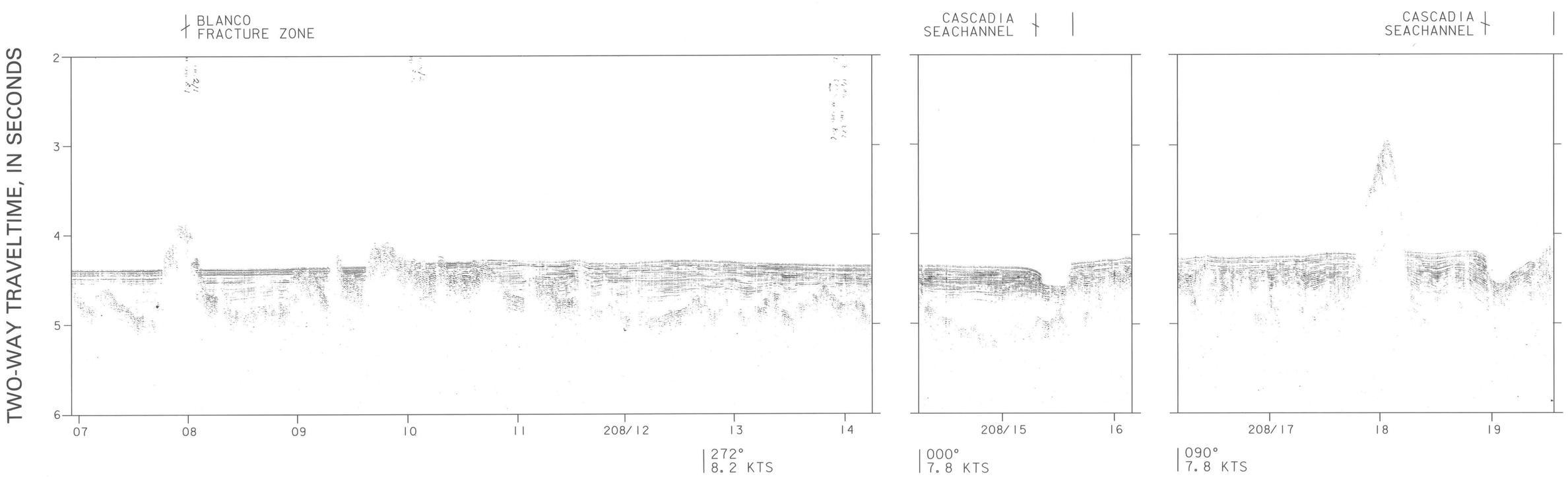

GORDA RIDGE
No data
204/08
09
10
11
204/12
13
204/14
15
16
17
18
19
274°
7.5 KTS
340°
7.0 KTS
090°
8.0 KTS
2
3
4
5
6

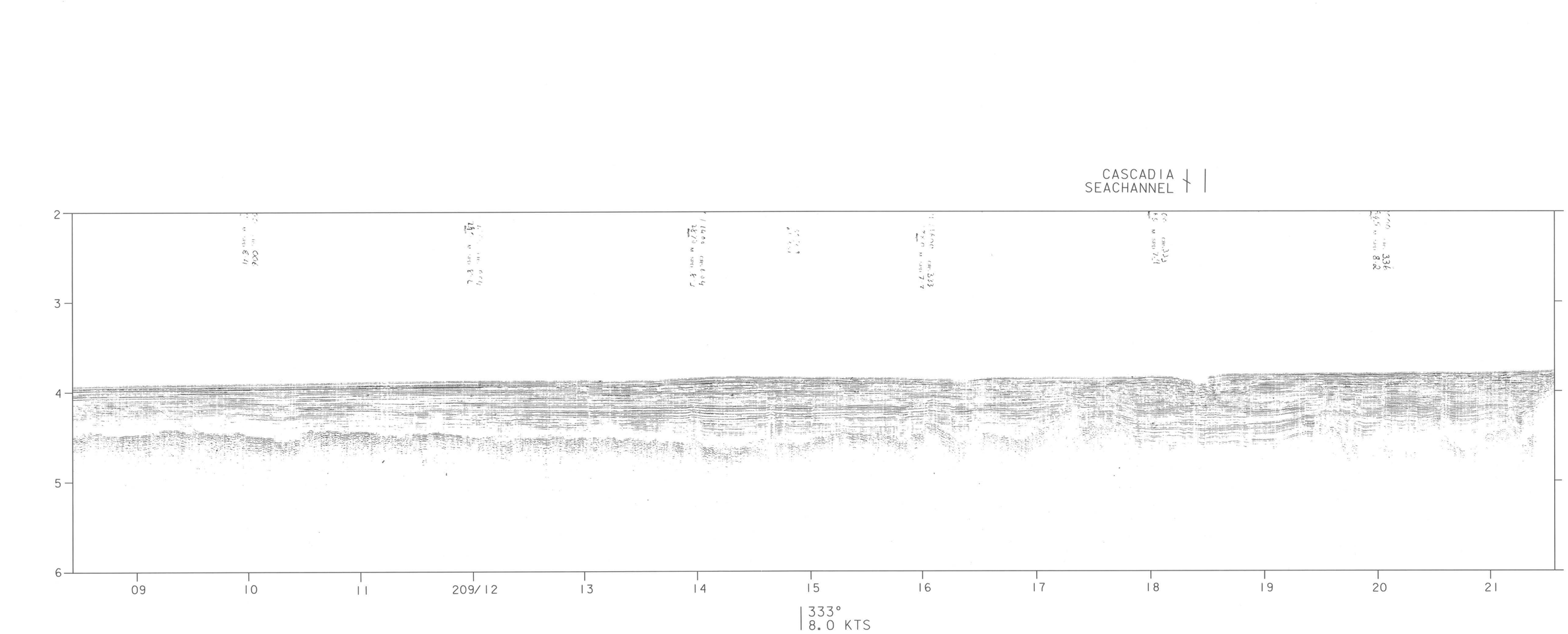

No data
09
10
11
205/12
13
14
15
16
17
012°
8.0 KTS
205/21
22
23
206/00
017°
8.2 KTS
333°
8.0 KTS
2
3
4
5
6
TWO-WAY TRAVELTIME, IN SECONDS


No data
206/15
206/16
17
206/18
19
20
21
22
23
207/00
01
207/04
243°
8.0 KTS
153°
8.3 KTS
2
3
4
5
6

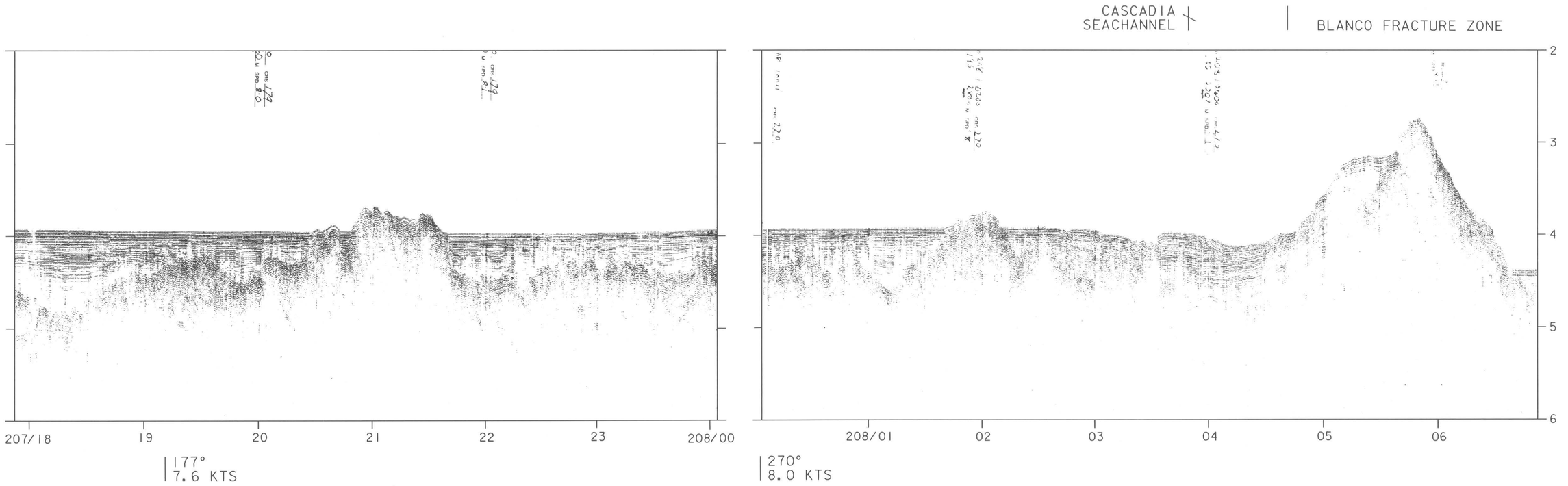
HOURS

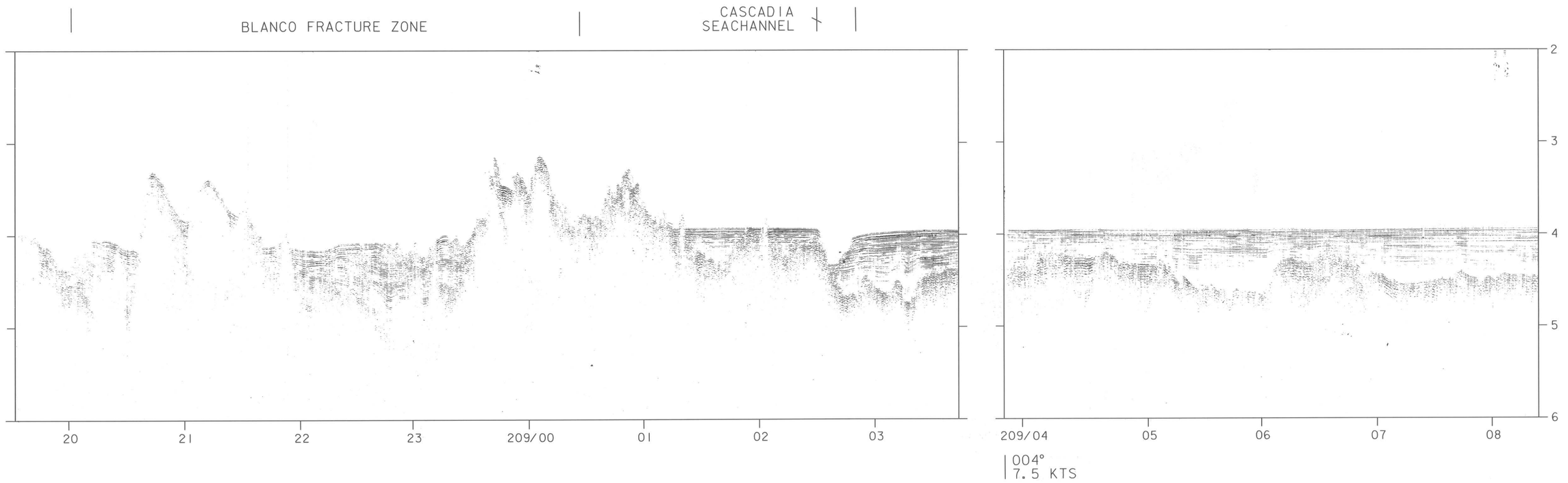

CASCADIA SEACHANNEL
2
3
4
5
6
05
06
07
08
09
10
11
207/12
13
14
15
16
17
153°
7.8 KTS
191°
8.4 KTS
177°
7.8 KTS

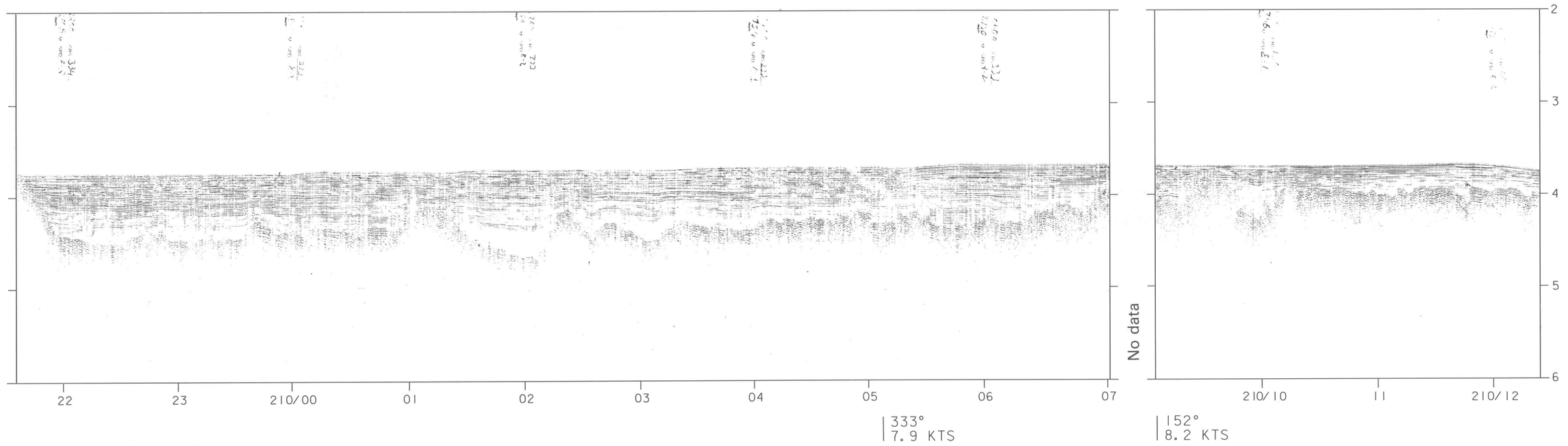

TWO-WAY TRAVELTIME, IN SECONDS
BLANCO FRACTURE ZONE
CASCADIA SEACHANNEL
CASCADIA SEACHANNEL
2
3
4
5
6
07
08
09
10
11
208/12
13
14
208/15
16
208/17
18
19
272°
8.2 KTS
000°
7.8 KTS
090°
7.8 KTS


CASCADIA SEACHANNEL
2
3
4
5
6
09
10
11
209/12
13
14
15
16
17
18
19
20
21
333°
8.0 KTS

HOURS


CASCADIA SEACHANNEL
BLANCO FRACTURE ZONE
207/18
19
20
21
22
23
208/00
177°
7.6 KTS
208/01
02
03
04
05
06
270°
8.0 KTS
2
3
4
5
6


BLANCO FRACTURE ZONE
CASCADIA SEACHANNEL
20
21
22
23
209/00
01
02
03
209/04
05
06
07
08
004°
7.5 KTS
2
3
4
5
6
TWO-WAY TRAVELTIME, IN SECONDS


22
23
210/00
01
02
03
04
05
06
07
333°
7.9 KTS
No data
210/10
11
210/12
152°
8.2 KTS
2
3
4
5
6

HOURS

CASCADIA SEACHANNEL

BLANCO FRACTURE ZONE

VANCOUVER VALLEY

TWO-WAY TRAVELTIME, IN SECONDS

2
3
4
5
6

210/13 14 15 16 17 18 19 20

150°
8.2 KTS

No data

211/05 06 07 08 09

152°
7.8 KTS

23 212/00 01 02

No data

212/06 07 08 09 10 11 212/12

270°
7.8 KTS

212/13 14

000°
8.2 KTS

213/04 05 06

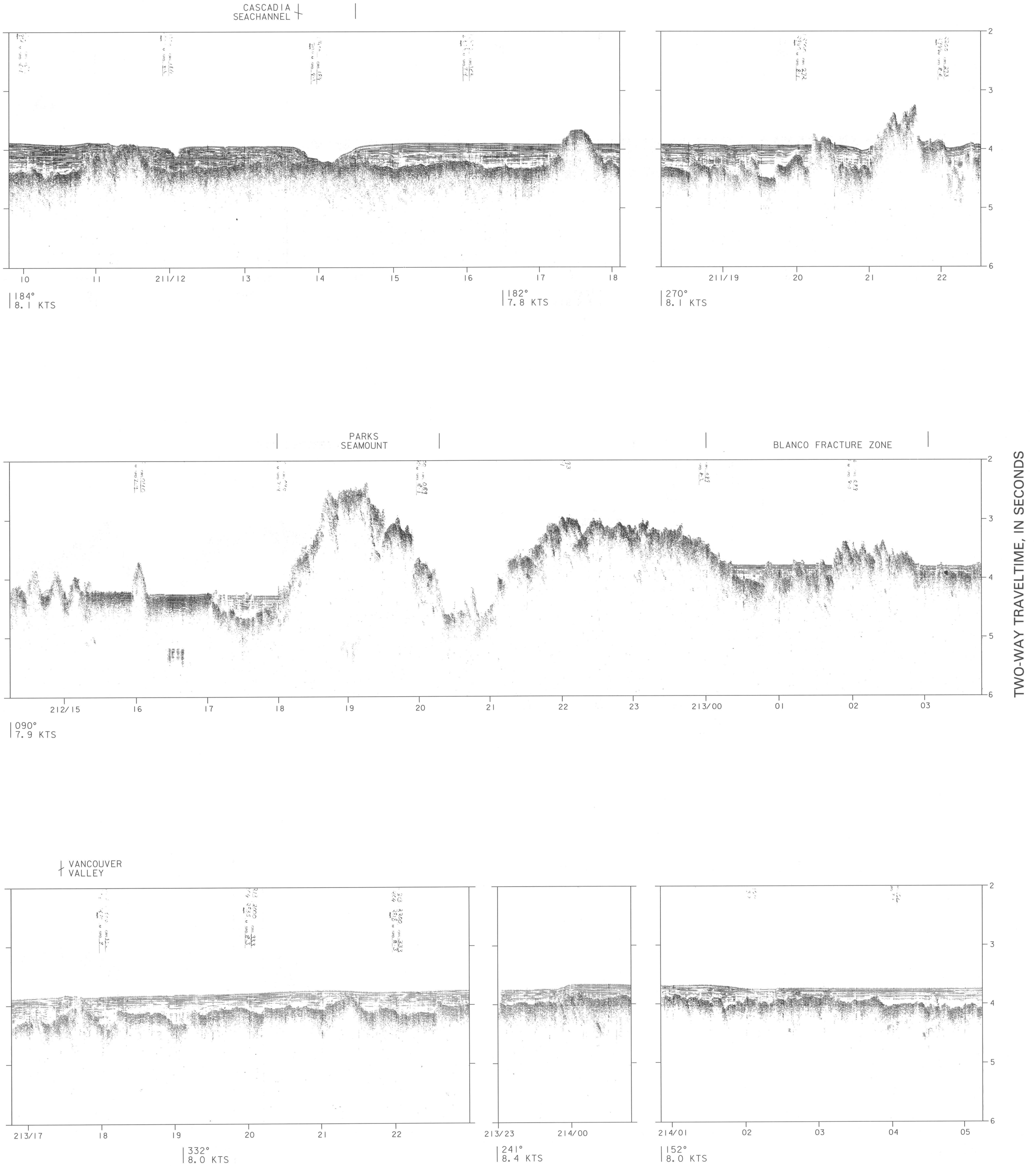
089°
8.0 KTS

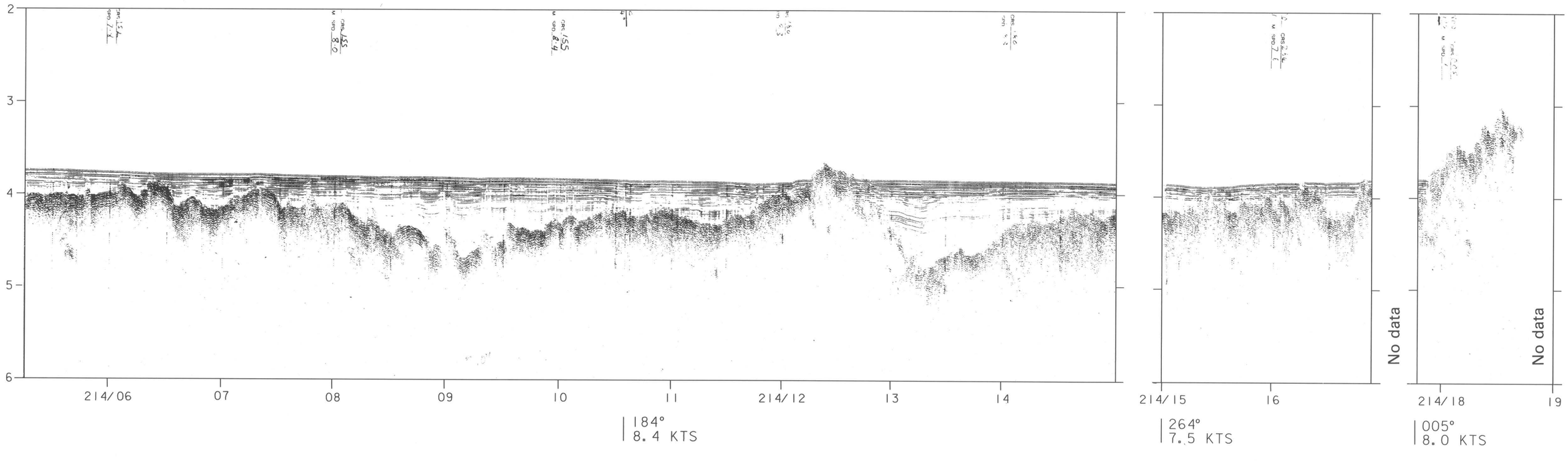
213/07 08 09 10 11 213/12 13 14 15 16

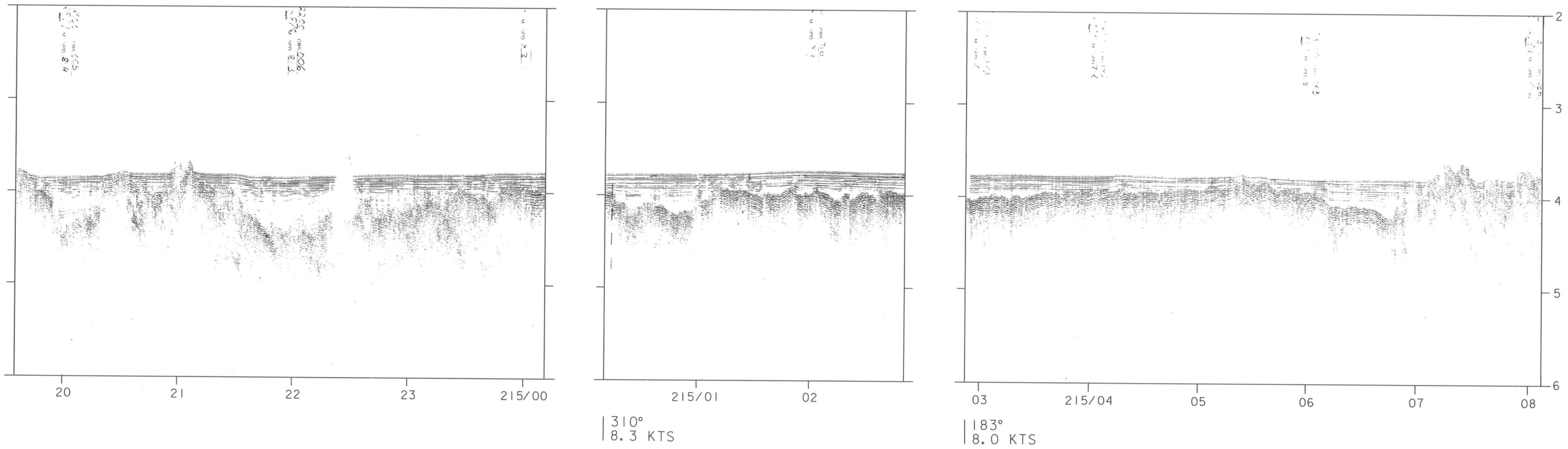
008°
8.3 KTS

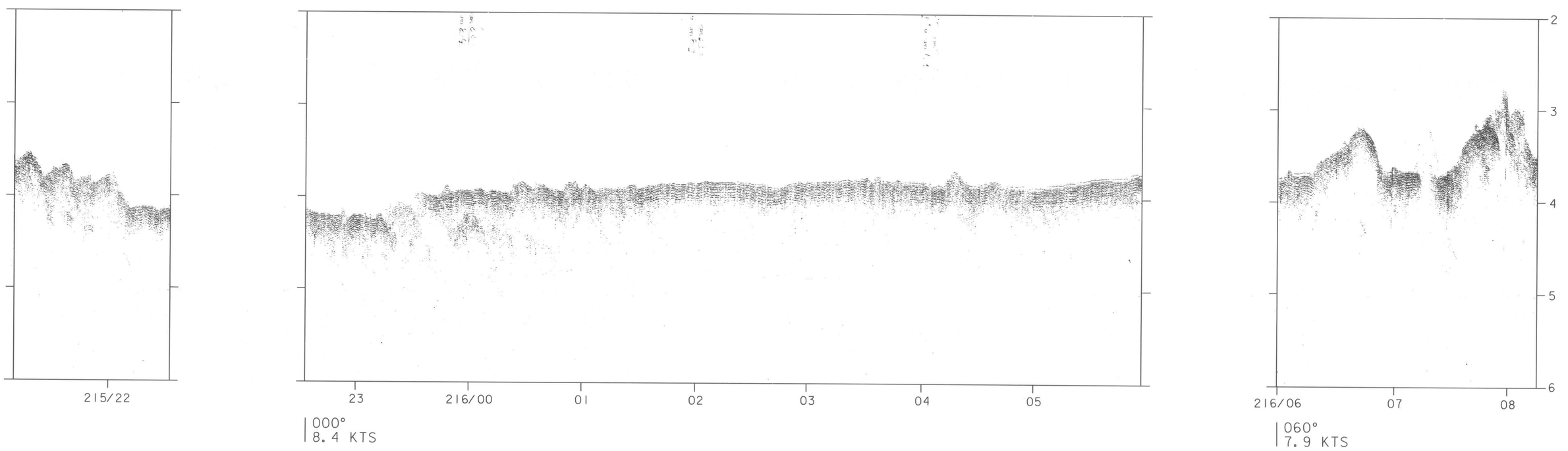
332°
8.0 KTS

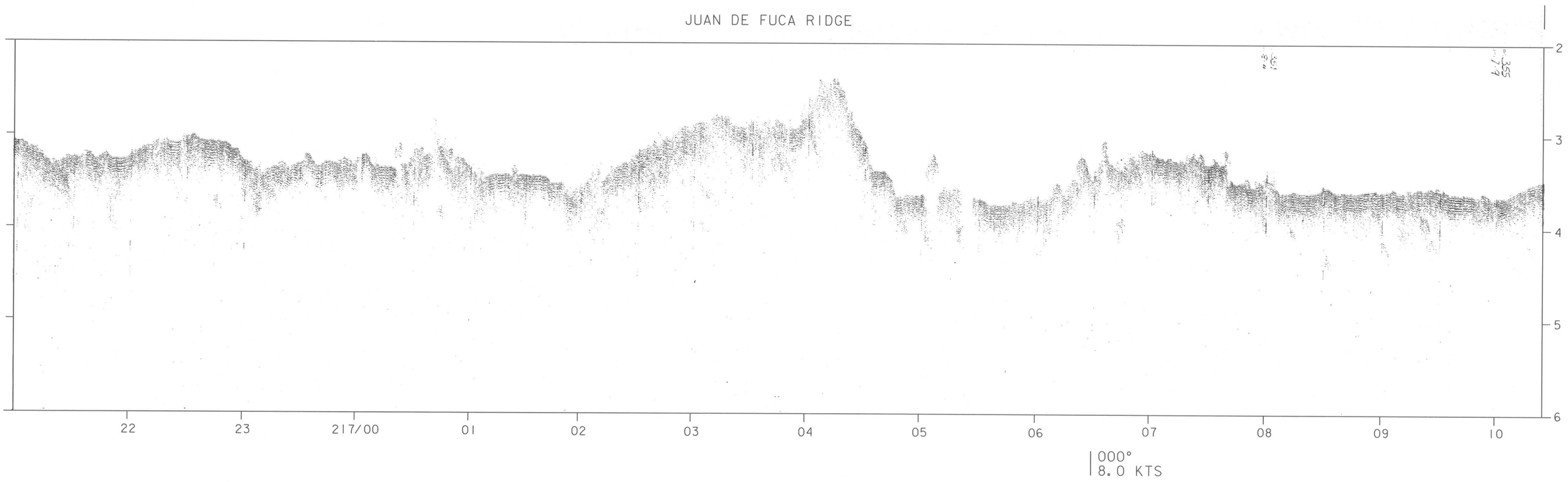
HOURS


CASCADIA SEACHANNEL
10
11
211/12
13
14
15
16
17
18
184°
8.1 KTS
182°
7.8 KTS
211/19
20
21
22
270°
8.1 KTS
PARKS SEAMOUNT
BLANCO FRACTURE ZONE
212/15
16
17
18
19
20
21
22
23
213/00
01
02
03
090°
7.9 KTS
2
3
4
5
6
TWO-WAY TRAVELTIME, IN SECONDS
VANCOUVER VALLEY
213/17
18
19
20
21
22
332°
8.0 KTS
213/23
214/00
241°
8.4 KTS
214/01
02
03
04
05
152°
8.0 KTS
HOURS


TWO-WAY TRAVELTIME, IN SECONDS
2
3
4
5
6
214/06
07
08
09
10
11
214/12
13
14
184°
8.4 KTS
214/15
16
264°
7.5 KTS
No data
214/18
19
005°
8.0 KTS
215/09
10
11
215/12
13
14
15
16
17
18
19
20
21
270°
8.1 KTS
BLANCO FRACTURE ZONE
VANCE SEAMOUNT
JUAN DE FUCA RIDGE
JUAN DE FUCA RIDGE
JUAN DE FUCA RIDGE
216/09
10
11
216/12
13
14
15
173°
7.9 KTS
216/16
17
090°
7.6 KTS
18
216/19
20
21
000°
8.0 KTS
HOURS

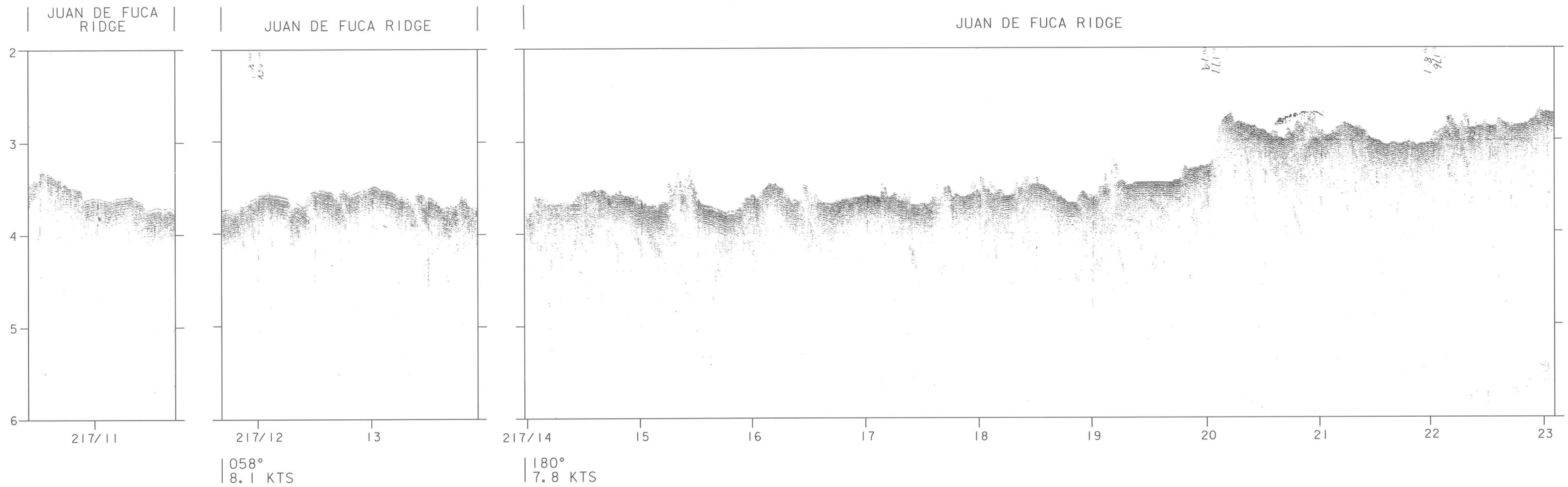

20
21
22
23
215/00
215/01
02
310°
8.3 KTS
03
215/04
05
06
07
08
183°
8.0 KTS
2
3
4
5
6

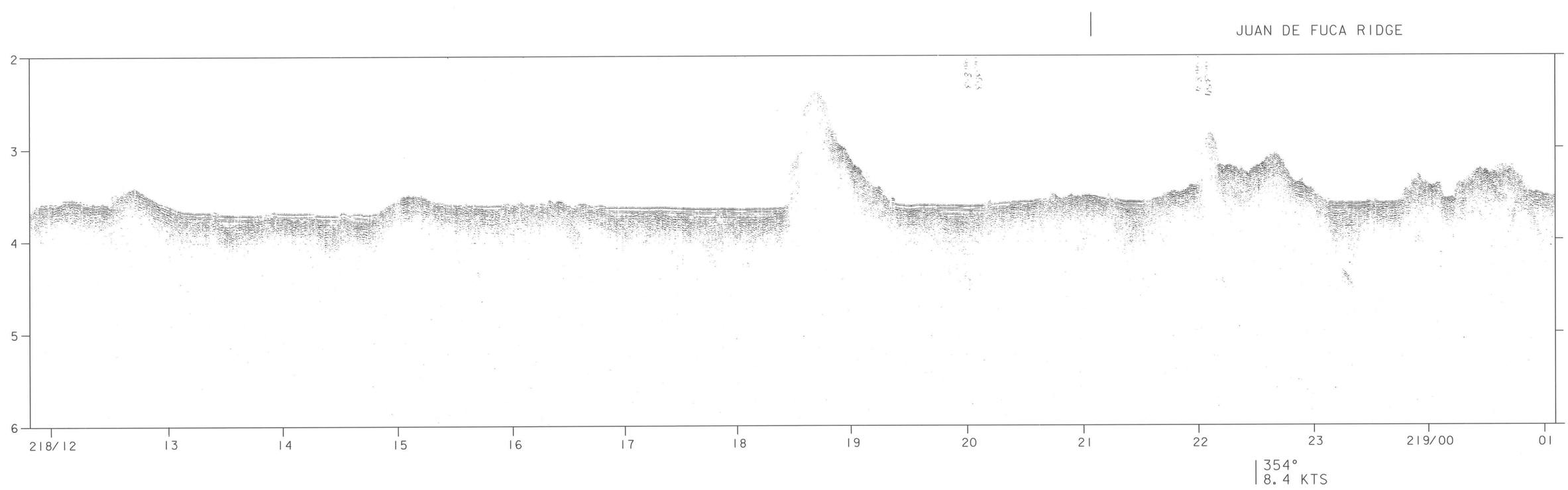

BLANCO
FRACTURE ZONE
215/22
23
216/00
01
02
03
04
05
000°
8.4 KTS
216/06
07
08
060°
7.9 KTS
2
3
4
5
6
TWO-WAY TRAVELTIME, IN SECONDS


JUAN DE FUCA RIDGE
22
23
217/00
01
02
03
04
05
06
07
08
09
10
000°
8.0 KTS
2
3
4
5
6

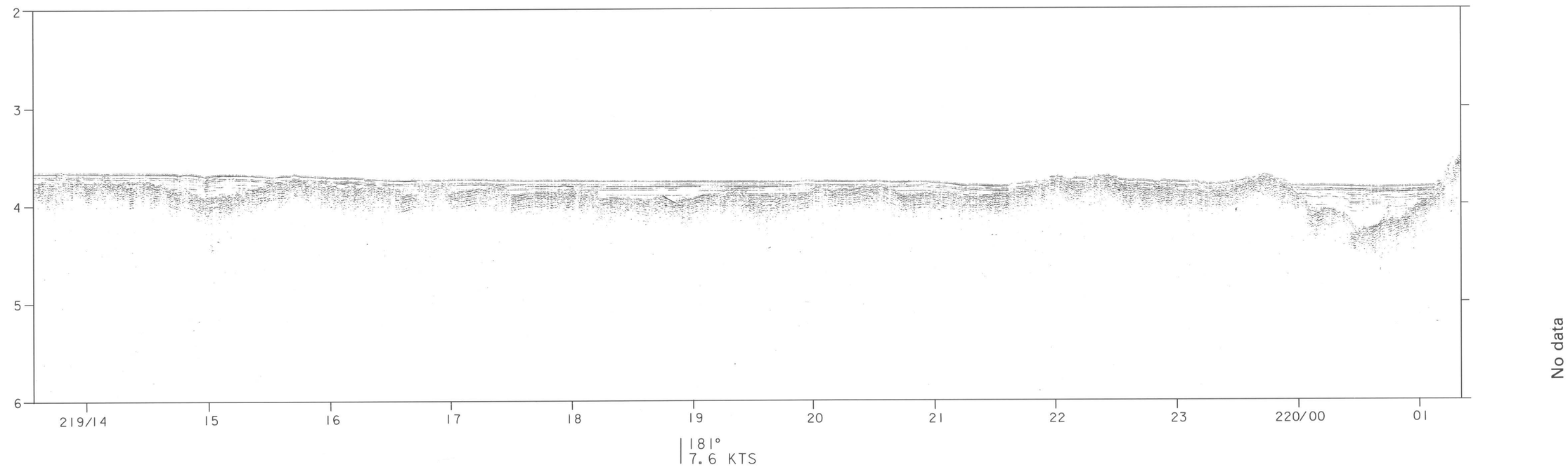
HOURS

DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY



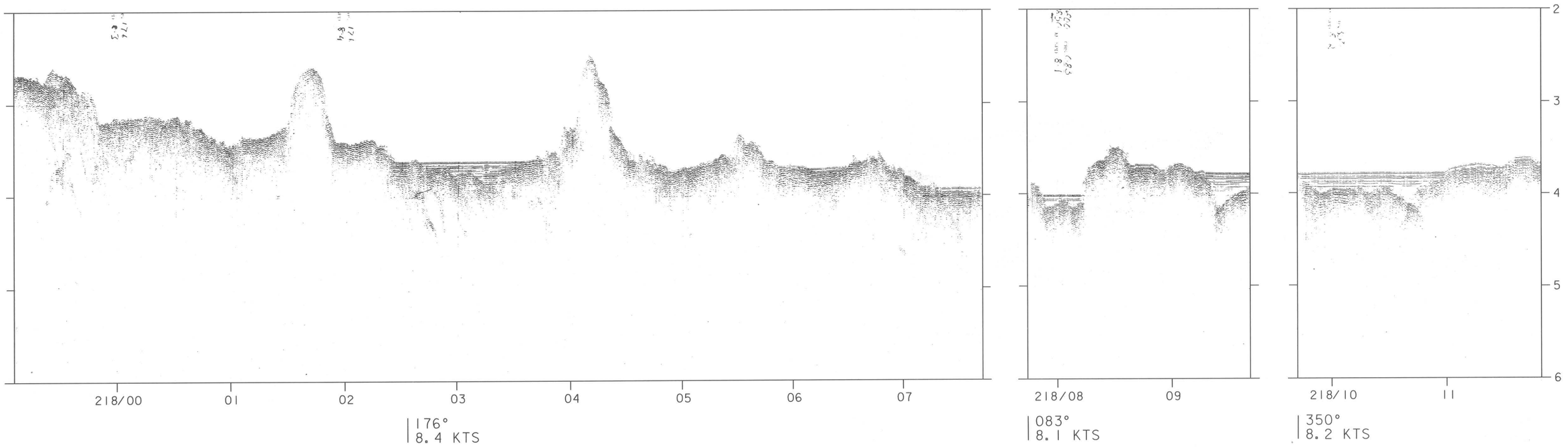


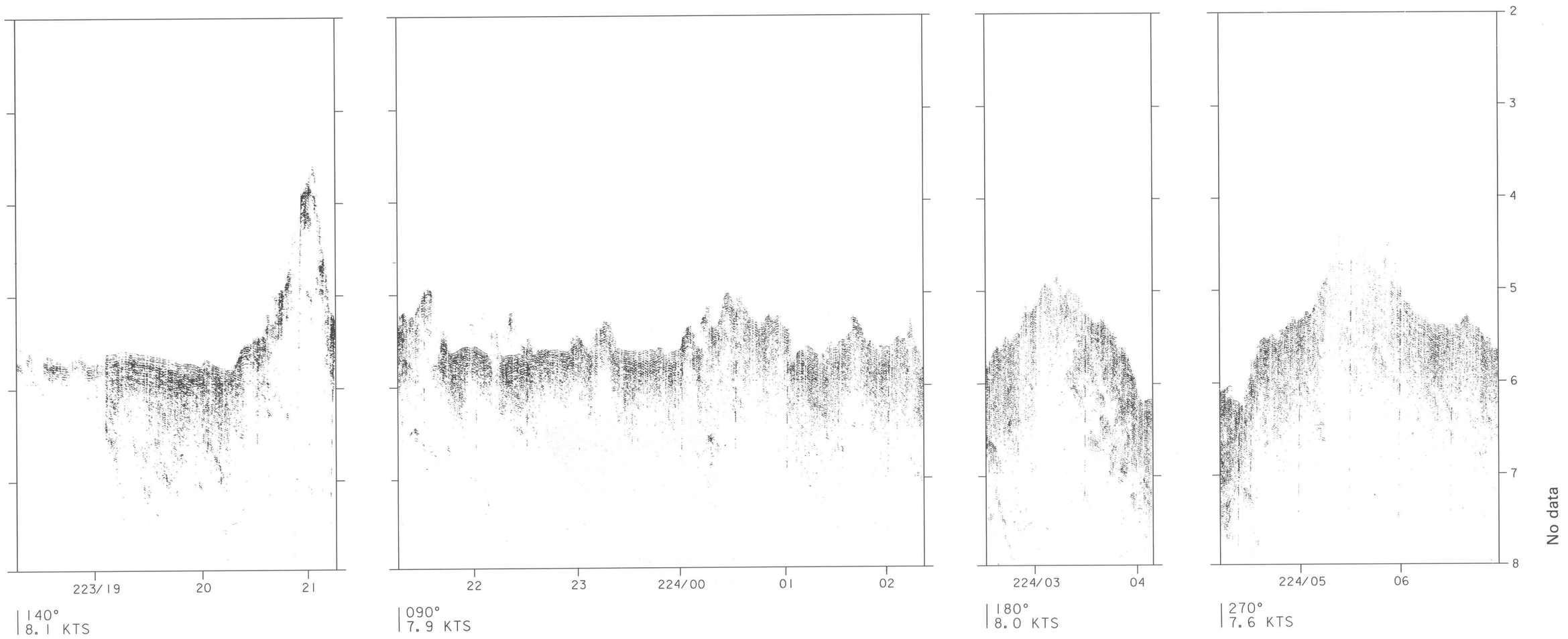
TWO-WAY TRAVELTIME, IN SECONDS

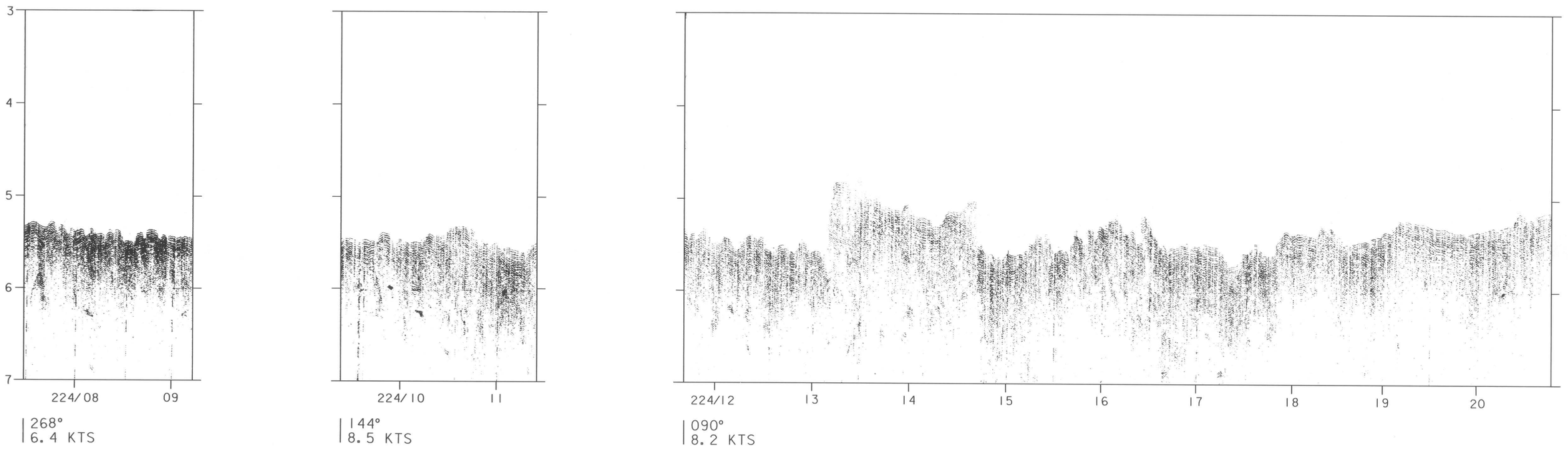


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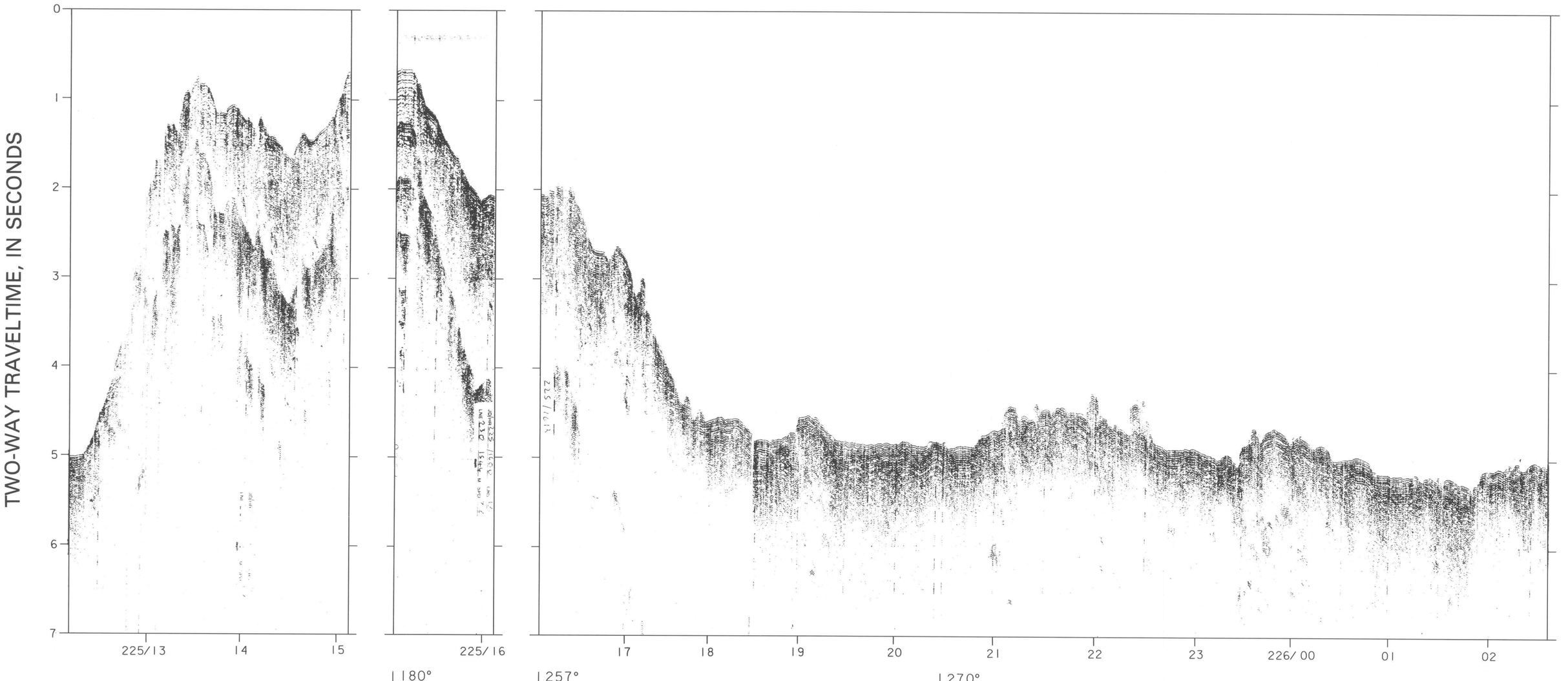
HOURS

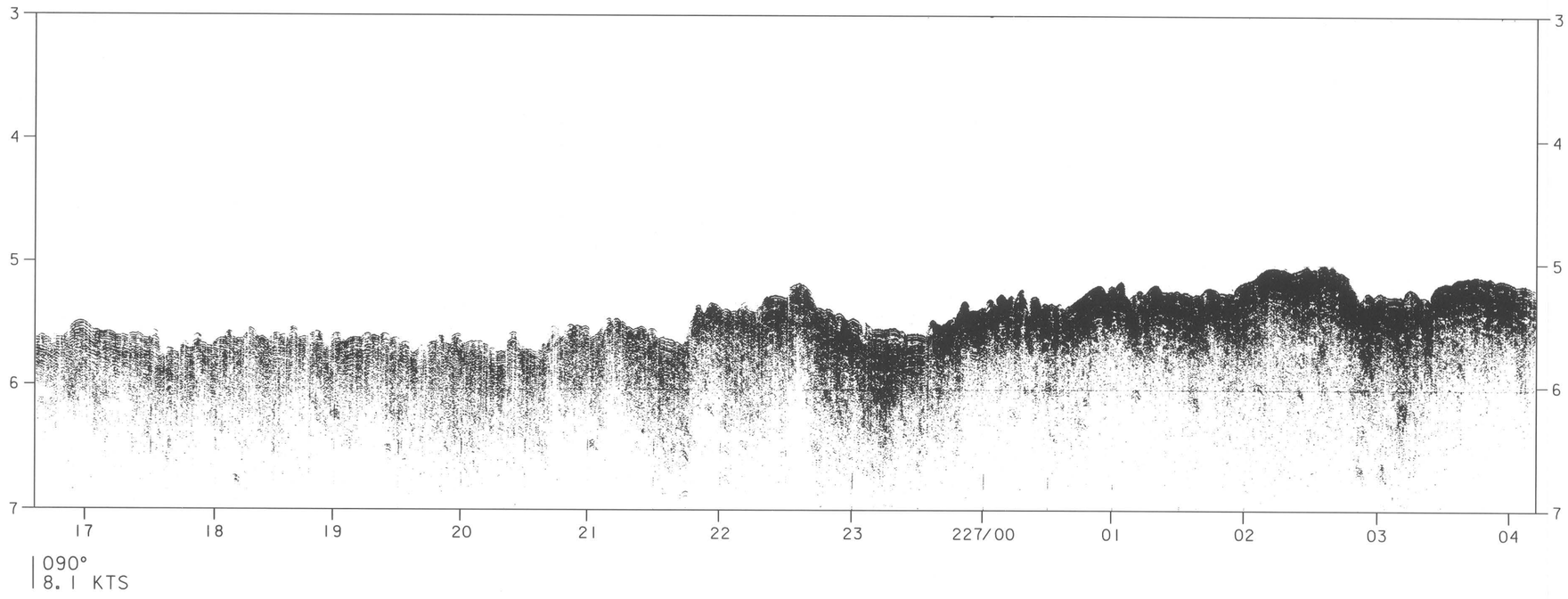

JUAN DE FUCA RIDGE
218/00
01
02
03
04
05
06
07
176°
8.4 KTS
JUAN DE FUCA RIDGE
218/08
09
083°
8.1 KTS
JUAN DE FUCA RIDGE
218/10
11
350°
8.2 KTS
JUAN DE FUCA RIDGE
219/02
03
04
JUAN DE FUCA RIDGE
219/05
06
090°
7.9 KTS
JUAN DE FUCA RIDGE
219/07
08
09
10
11
219/12
13
174°
8.3 KTS
2
3
4
5
6
TWO-WAY TRAVELTIME, IN SECONDS


223/19
20
21
140°
8.1 KTS
22
23
224/00
01
02
090°
7.9 KTS
224/03
04
180°
8.0 KTS
224/05
06
270°
7.6 KTS
2
3
4
5
6
7
8
No data
HOURS

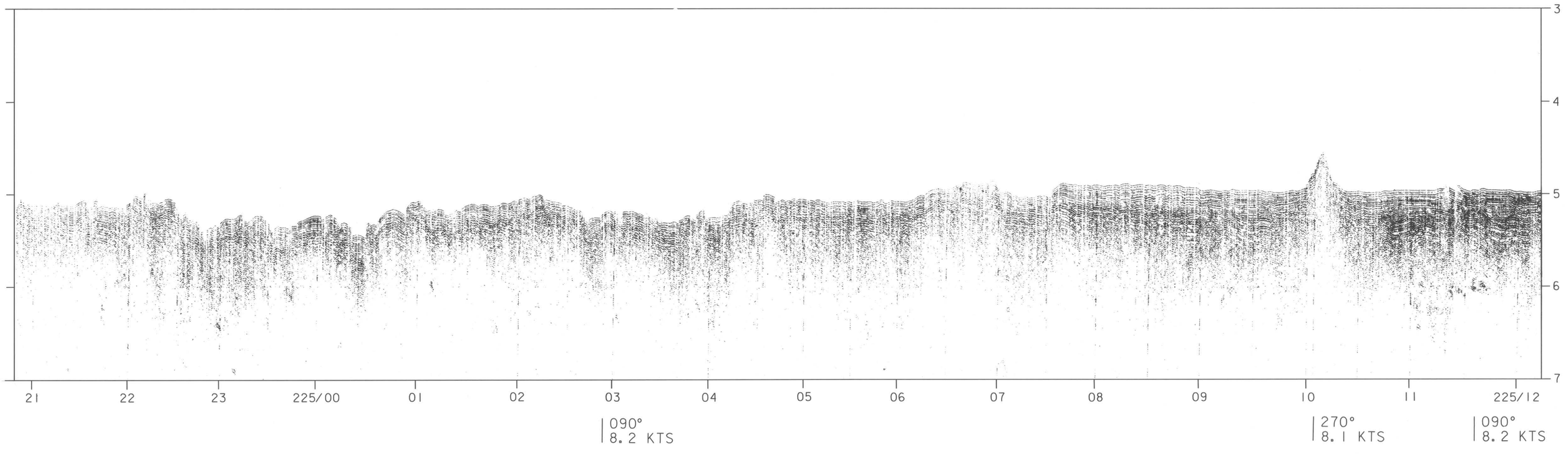


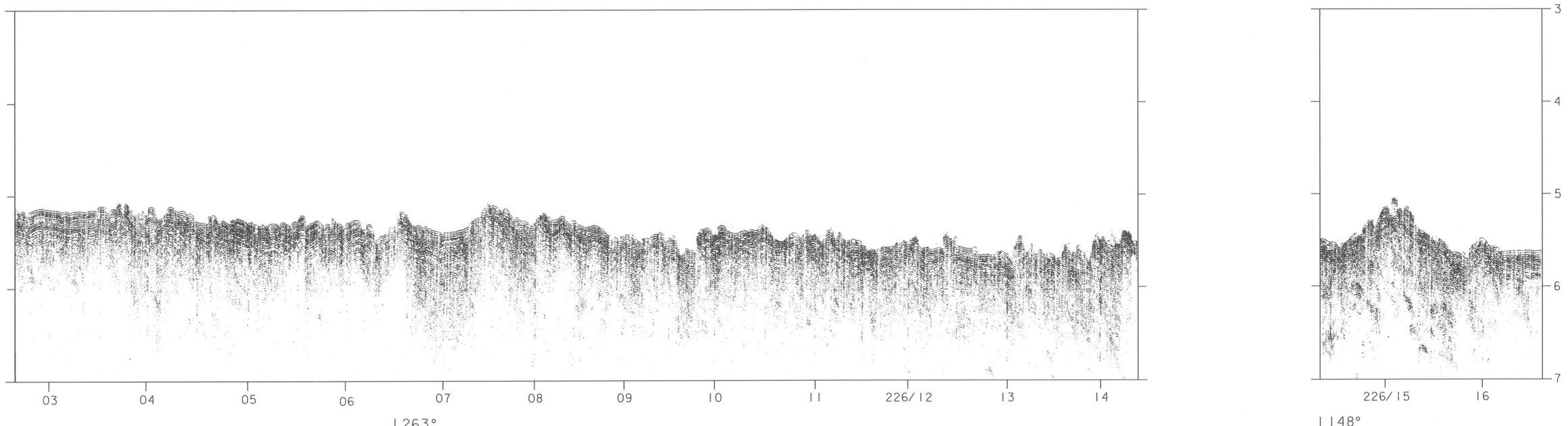
PATTON ESCARPMENT





HOURS

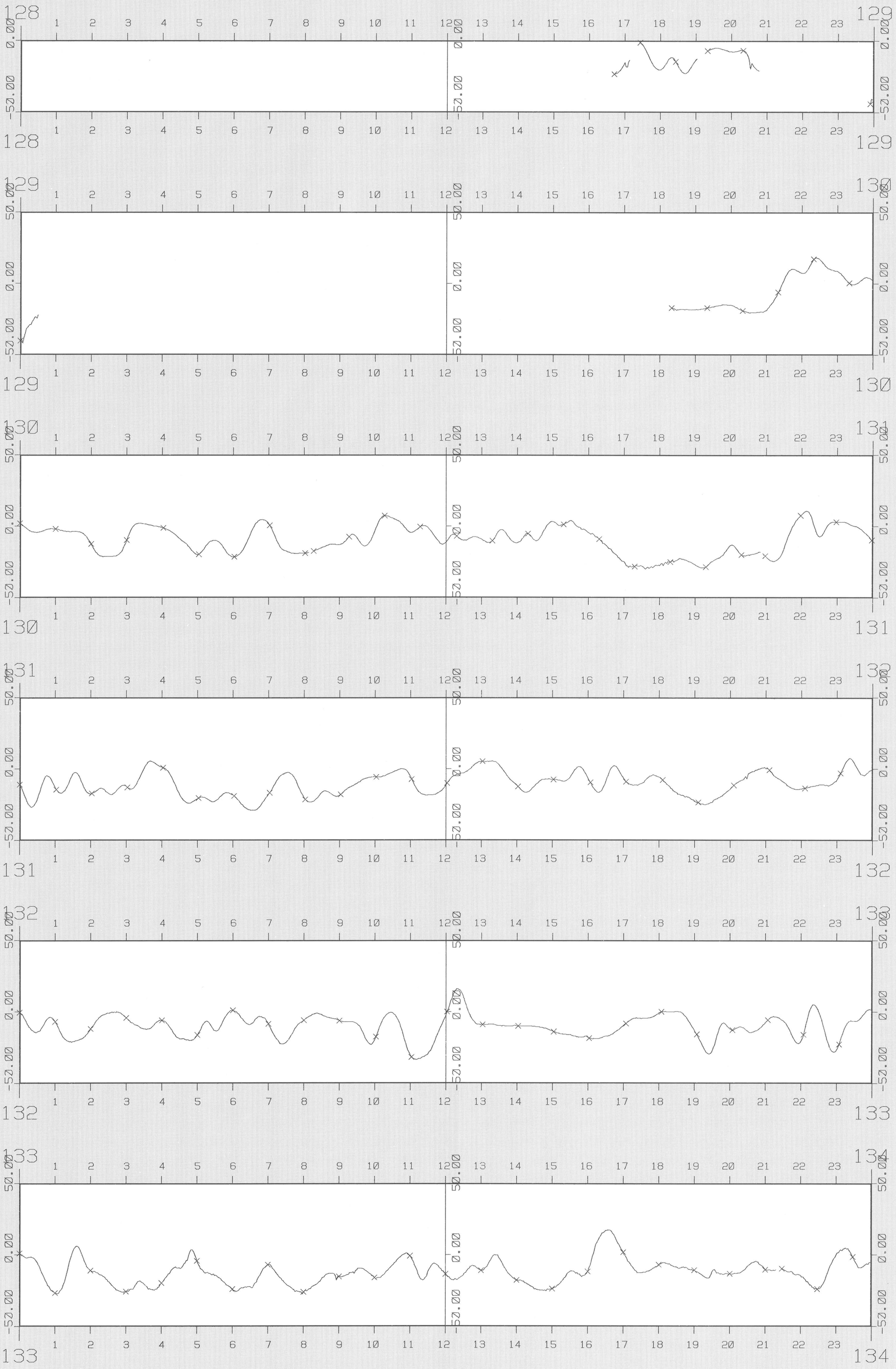

3
4
5
6
7
21
22
23
225/00
01
02
03
04
05
06
07
08
09
10
11
225/12
090°
8.2 KTS
270°
8.1 KTS
090°
8.2 KTS

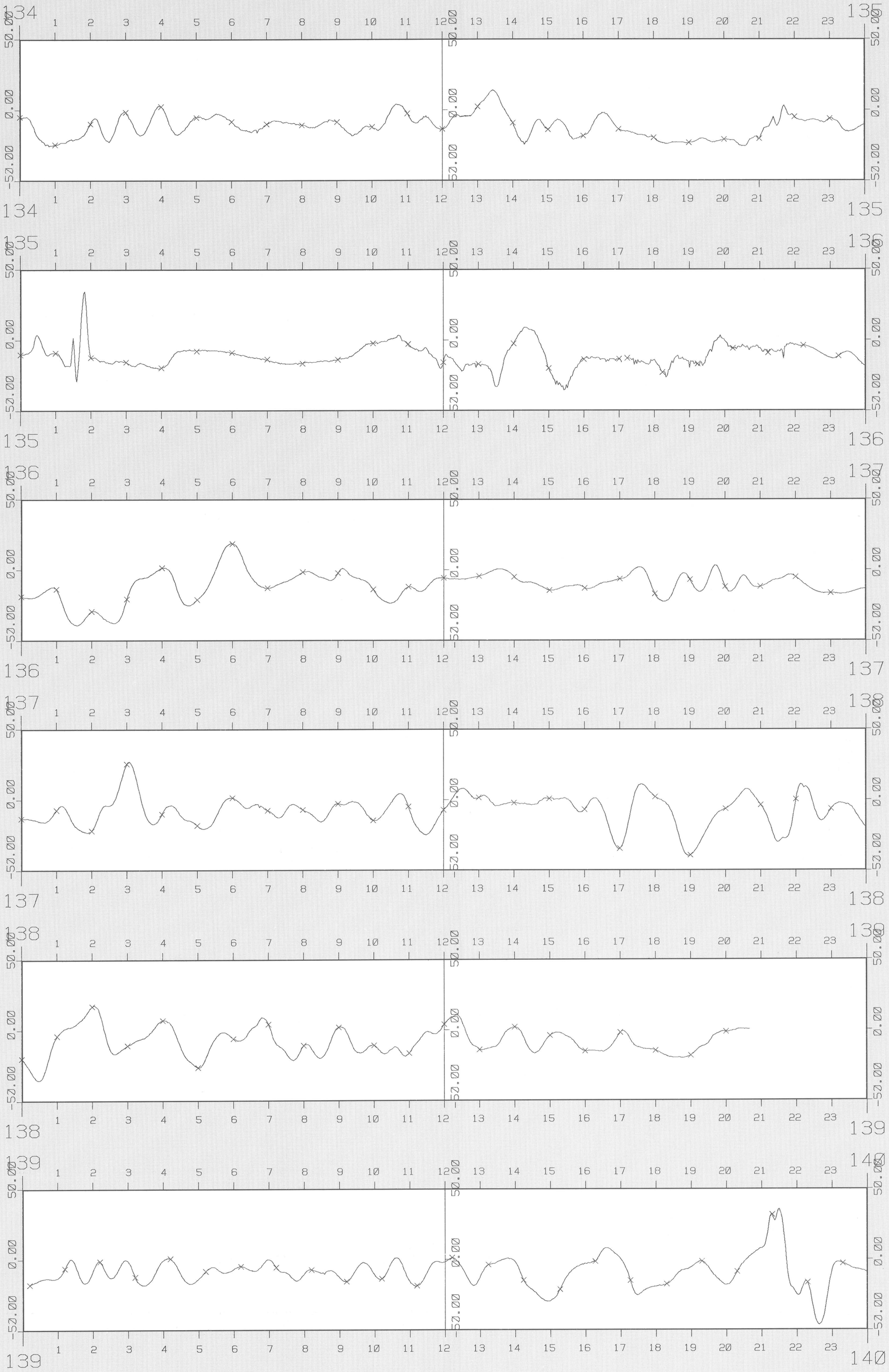

3
4
5
6
7
03
04
05
06
07
08
09
10
11
226/12
13
14
263°
8.0 KTS
226/15
16
148°
8.1 KTS
TWO-WAY TRAVELTIME, IN SECONDS

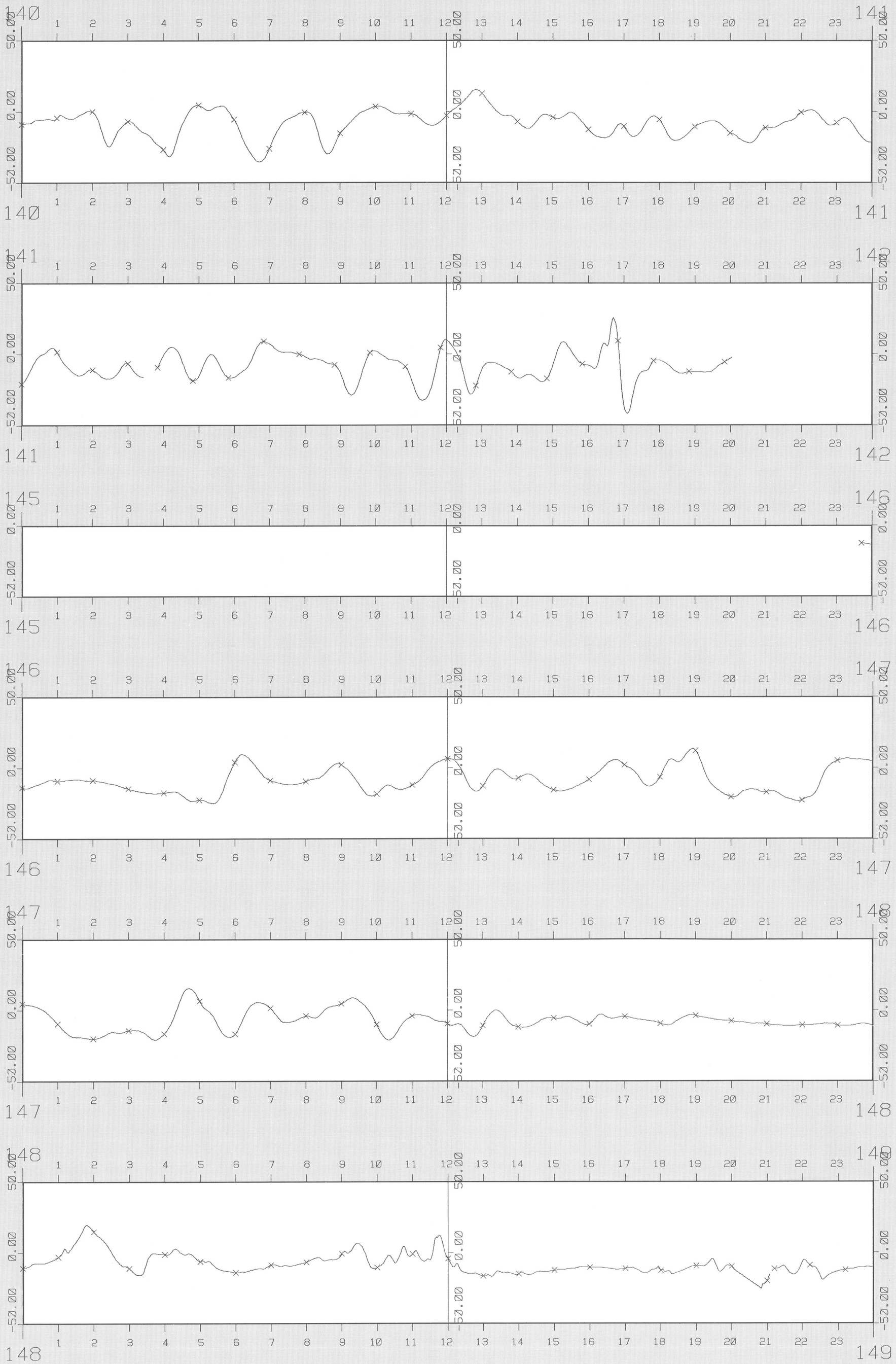
HOURS

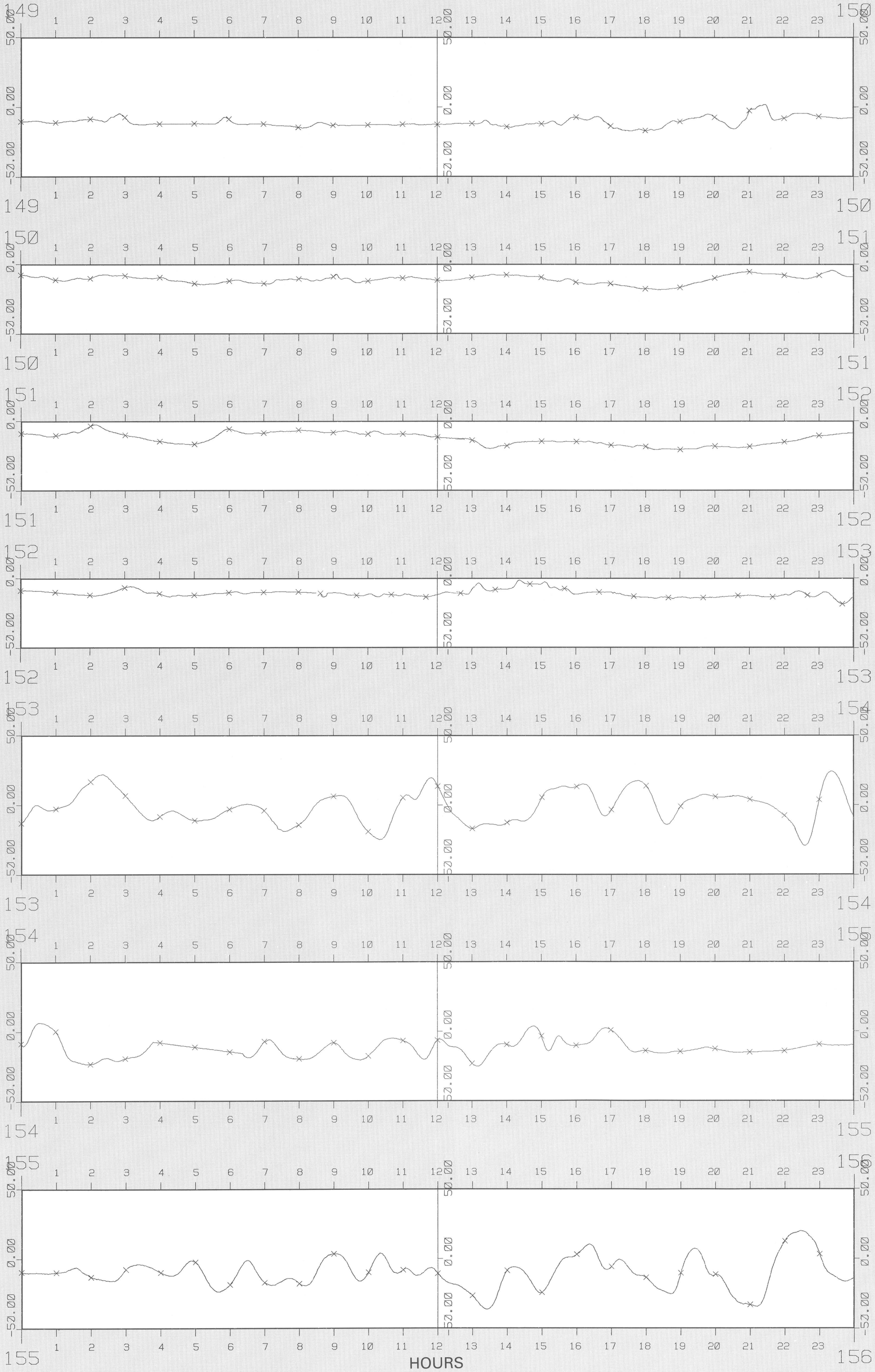
MAGNETIC PROFILES

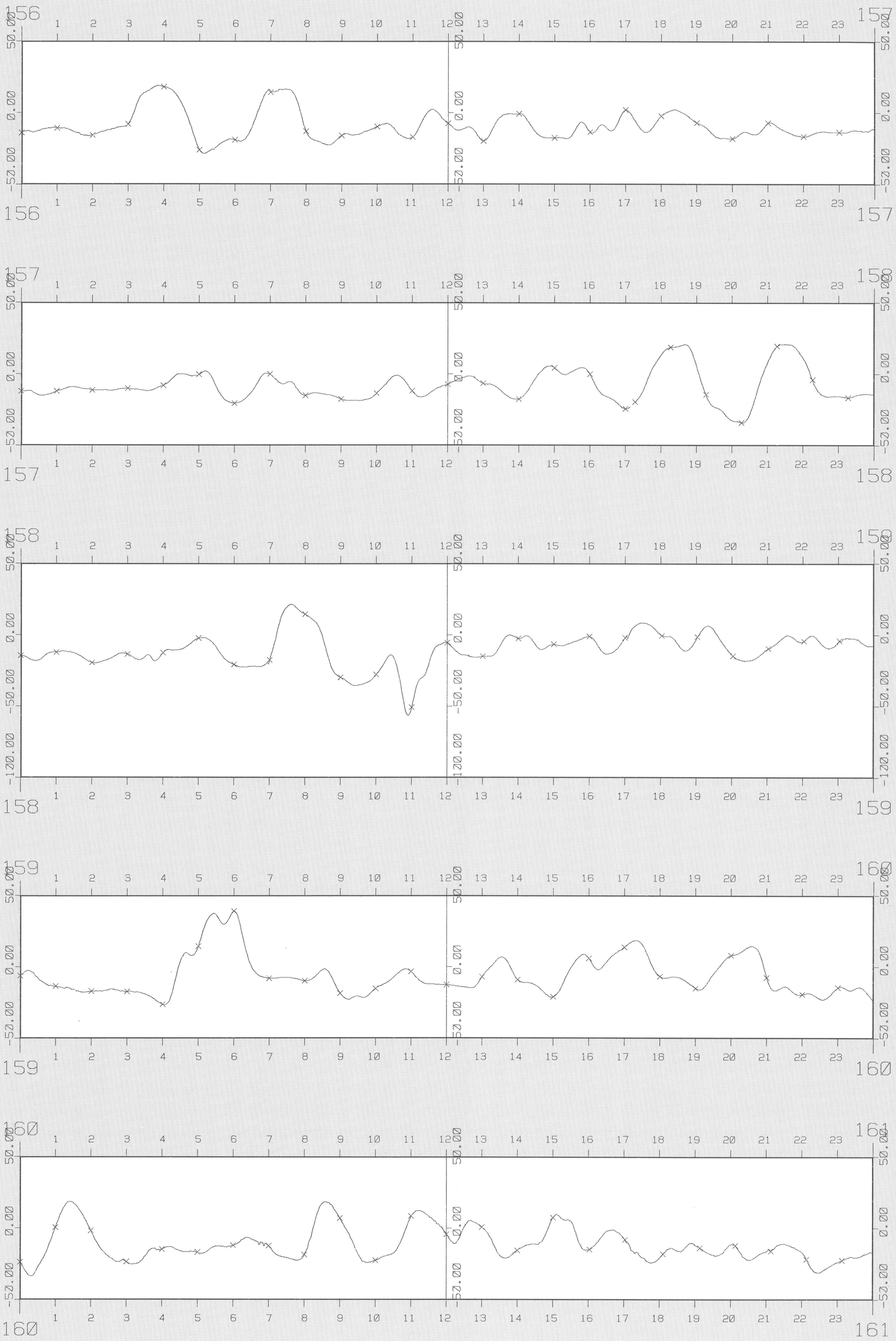
MAGNETIC PROFILES

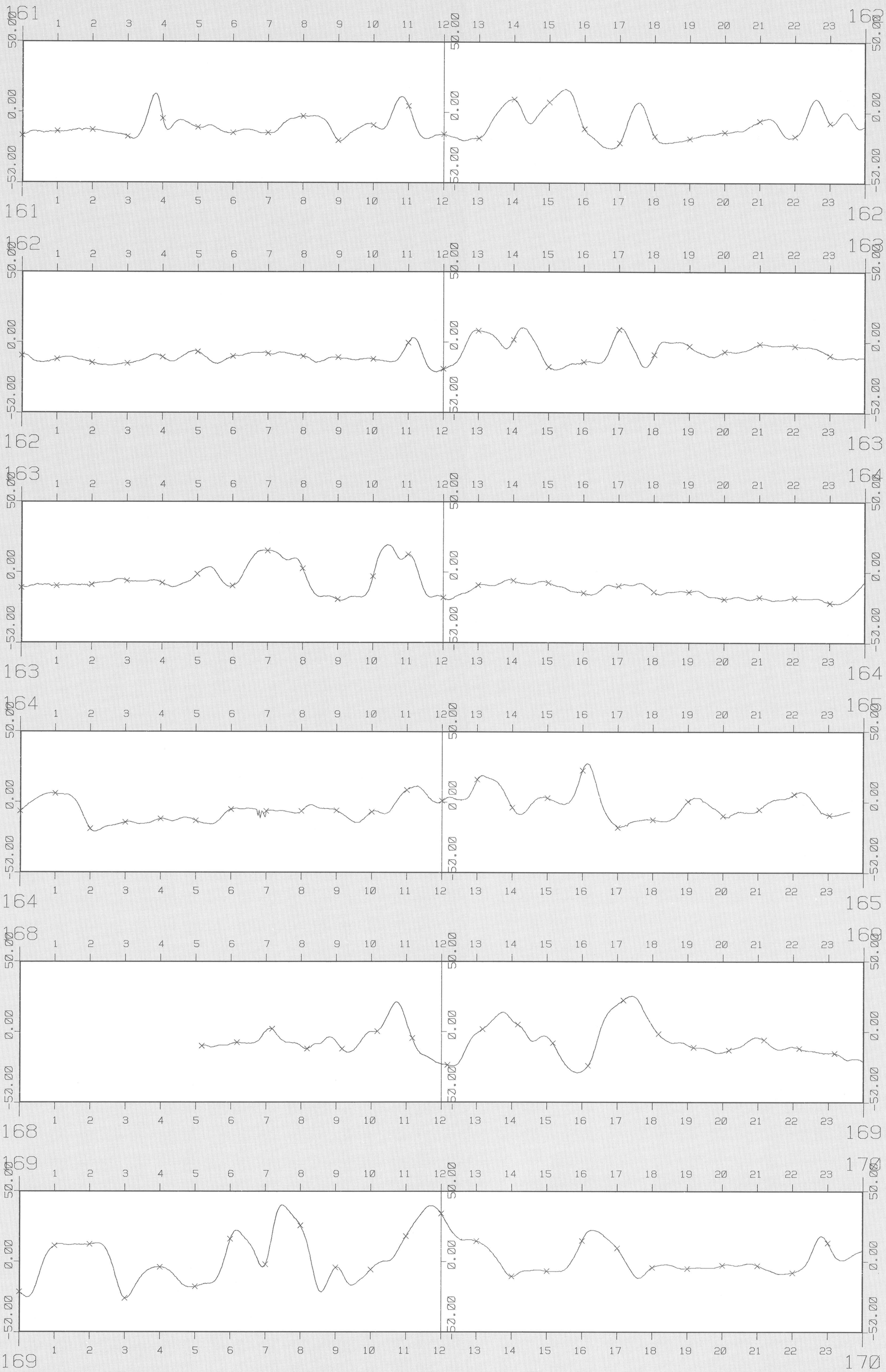

128
129
130
131
132
133
134
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23
50.00
0.00
-50.00
RESIDUAL MAGNETIC ANOMALY, IN GAMMAS (X 100)
HOURS

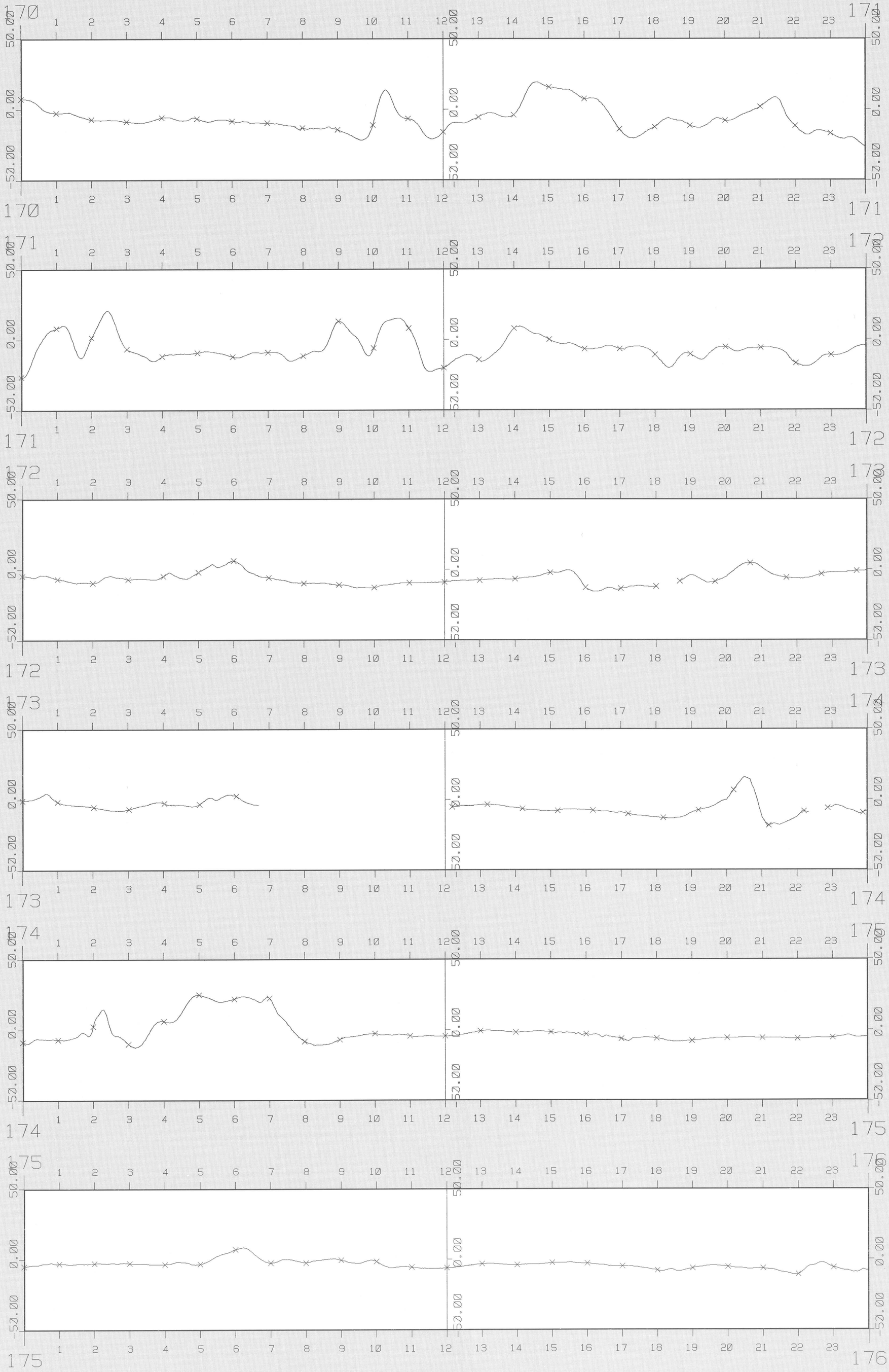

RESIDUAL MAGNETIC ANOMALY, IN GAMMAS (X 100)
50.00
0.00
-50.00
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23
134
135
136
137
138
139
140
HOURS

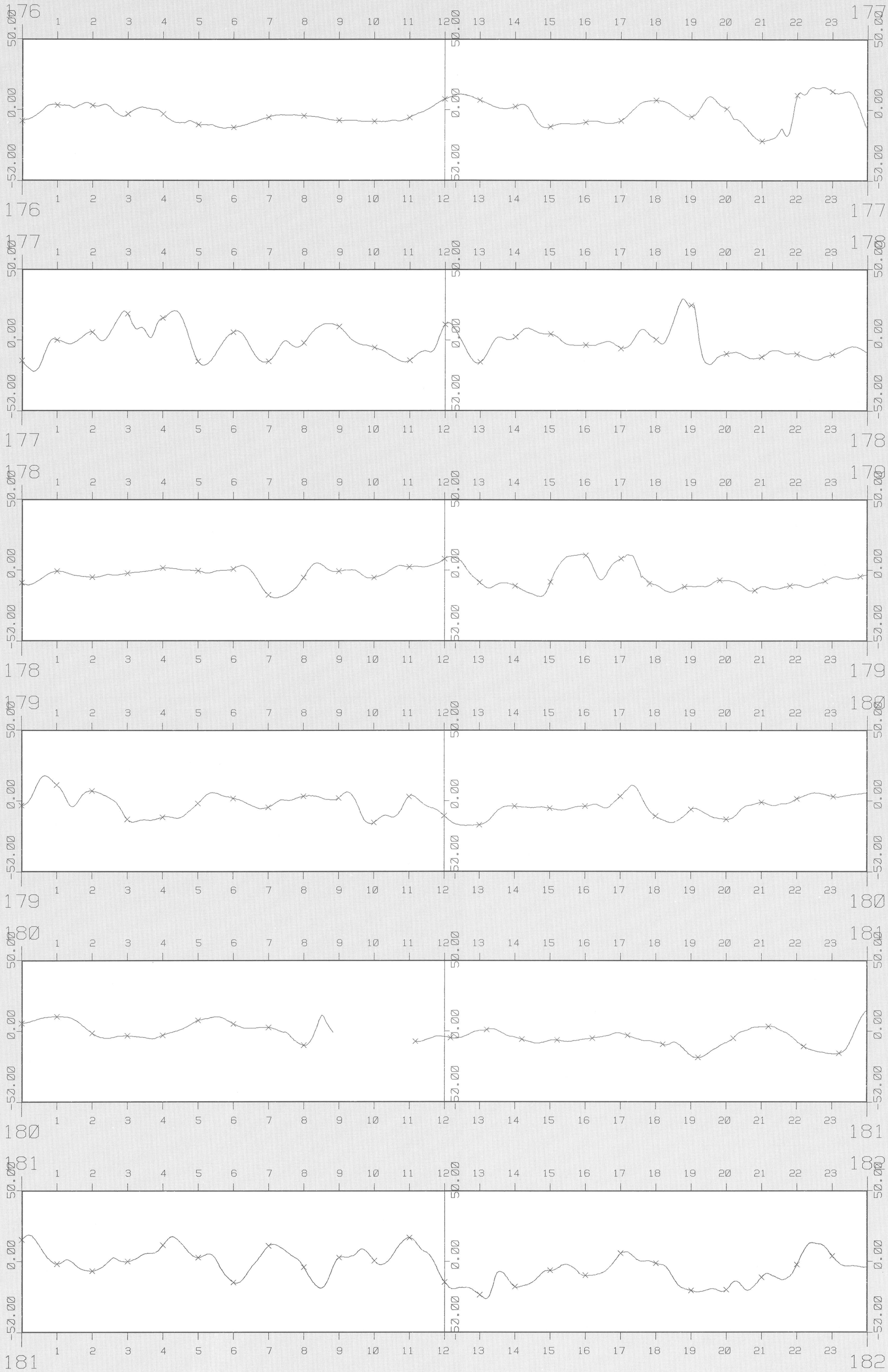

RESIDUAL MAGNETIC ANOMALY, IN GAMMAS (X 100)
140
141
142
145
146
147
148
149
50.00
0.00
-50.00
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23
HOURS

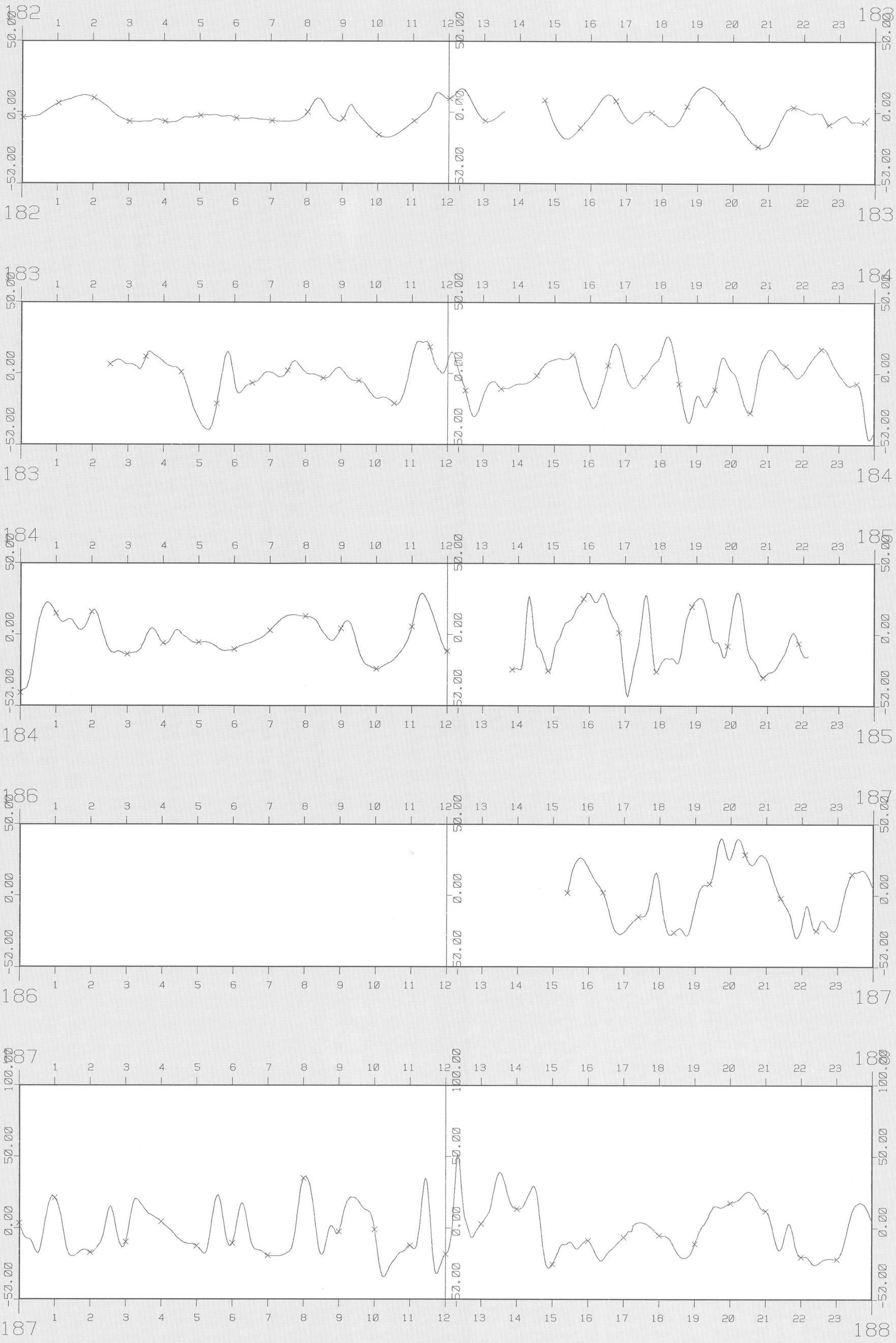

RESIDUAL MAGNETIC ANOMALY, IN GAMMAS (X 100)
HOURS
149
150
151
152
153
154
155
156
50.00
0.00
-50.00
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23


RESIDUAL MAGNETIC ANOMALY, IN GAMMAS (X 100)
HOURS
156
157
158
159
160
161


RESIDUAL MAGNETIC ANOMALY, IN GAMMAS (X 100)
HOURS
161
162
163
164
165
166
167
168
169
170
50.00
0.00
-50.00
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23

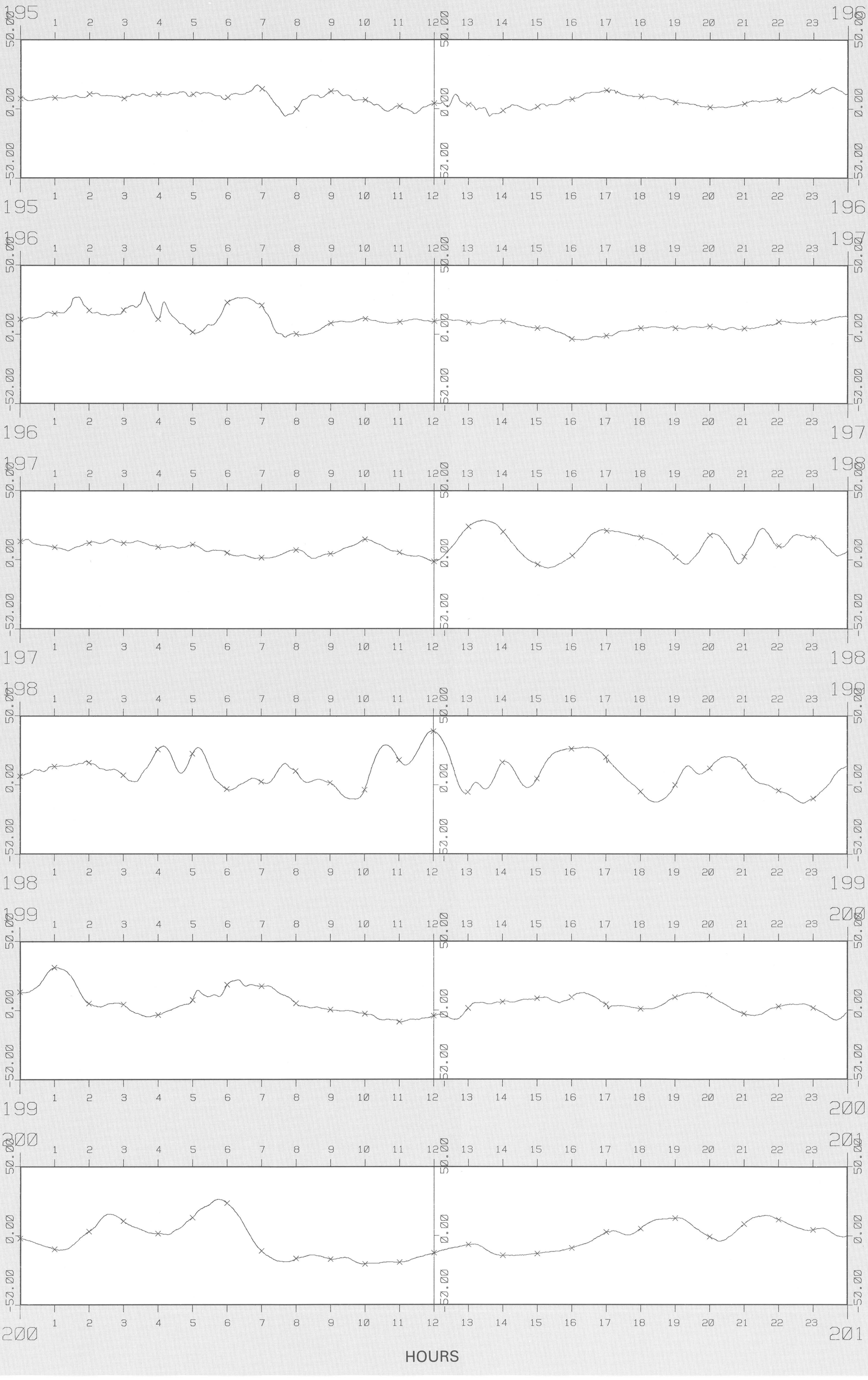

RESIDUAL MAGNETIC ANOMALY, IN GAMMAS (X 100)
50.00
0.00
-50.00
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23
170
171
172
173
174
175
176
HOURS

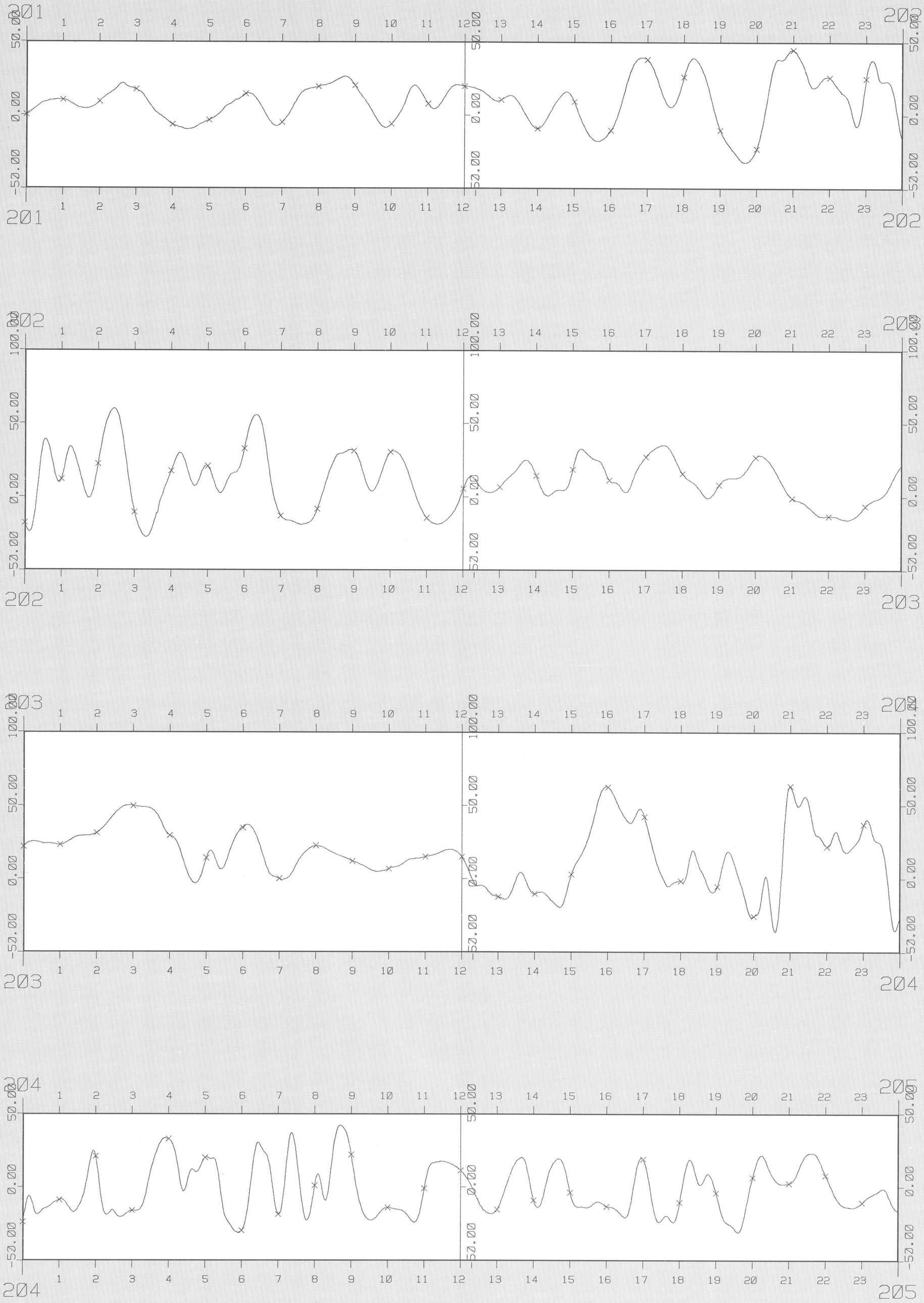

RESIDUAL MAGNETIC ANOMALY, IN GAMMAS (X 100)
HOURS
176
177
178
179
180
181
182
50.00
0.00
-50.00
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23

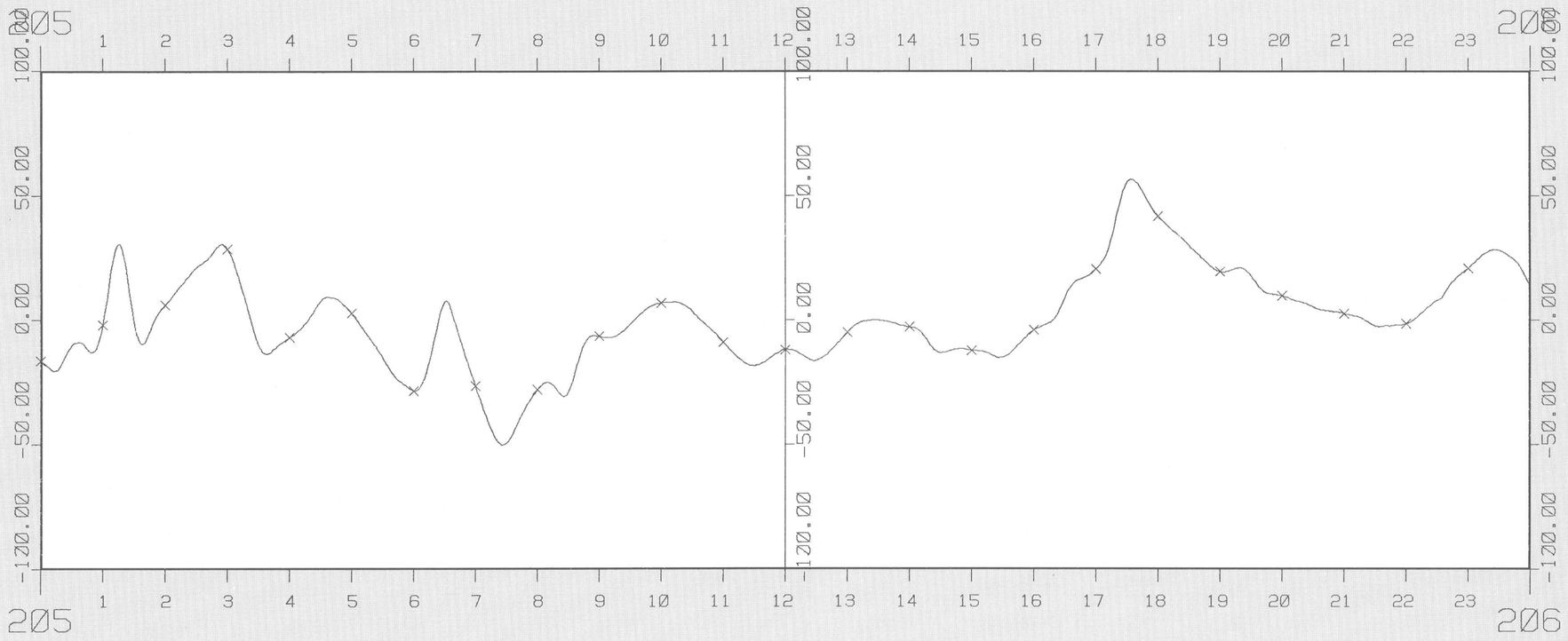

RESIDUAL MAGNETIC ANOMALY, IN GAMMAS (X 100)
HOURS
182
183
184
185
186
187
188
50.00
0.00
-50.00
100.00
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23

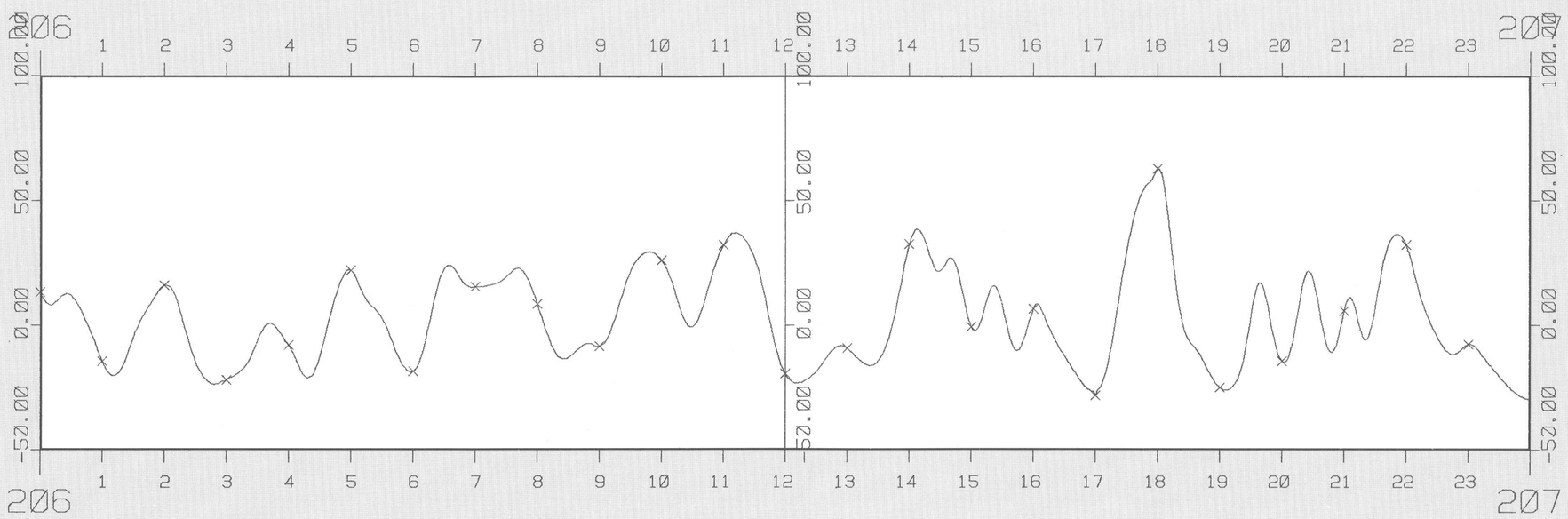
RESIDUAL MAGNETIC ANOMALY, IN GAMMAS (X 100)

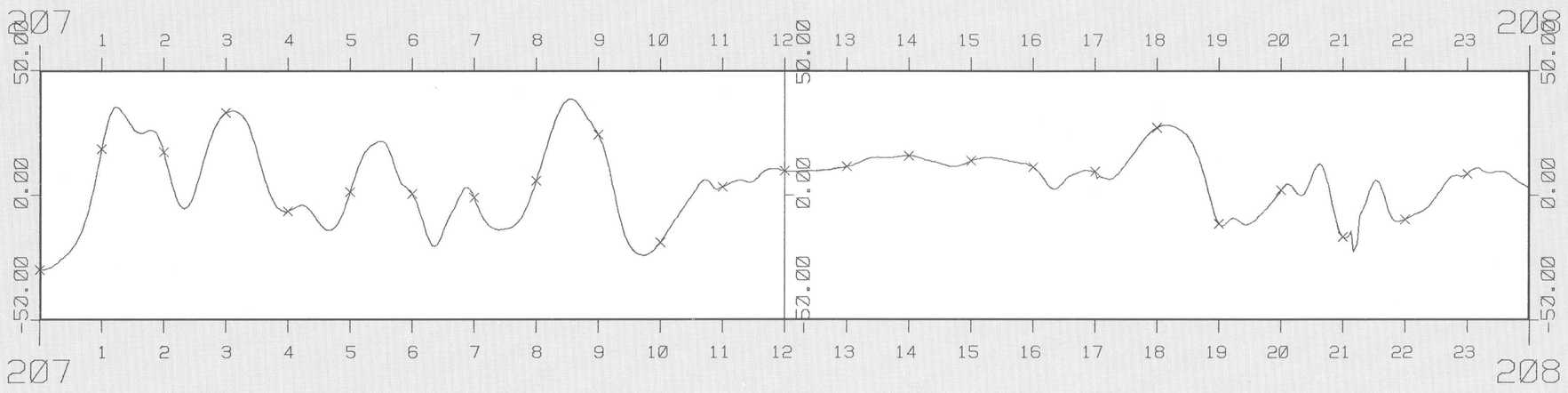
HOURS

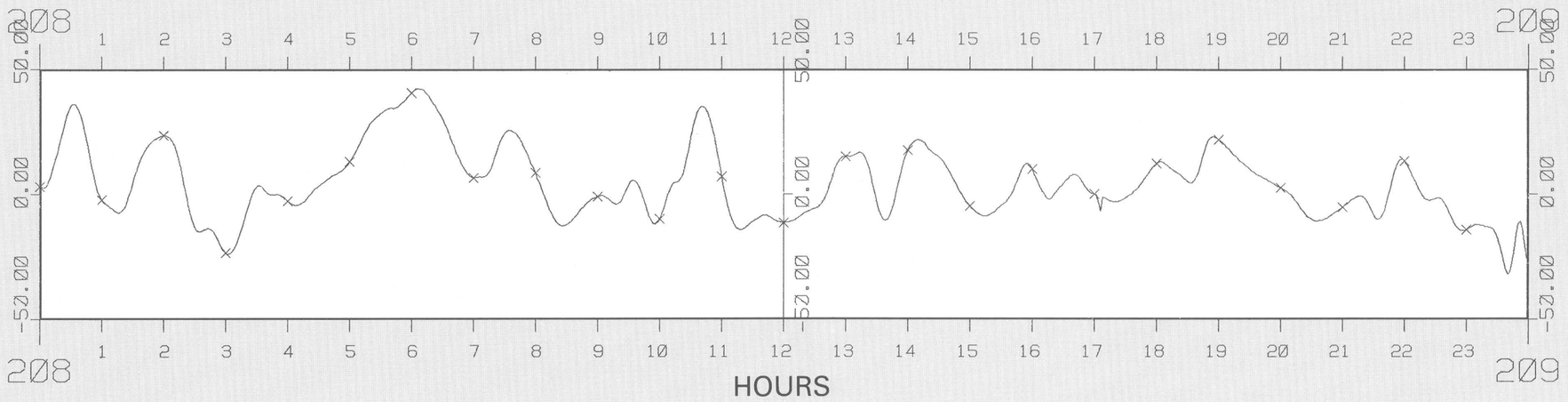

RESIDUAL MAGNETIC ANOMALY, IN GAMMAS (X 100)
50.00
0.00
-50.00
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23
195
196
197
198
199
200
201
HOURS


201
202
202
203
203
204
204
205
RESIDUAL MAGNETIC ANOMALY, IN GAMMAS (X 100)
50.00
0.00
-50.00
100.00
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23
HOURS



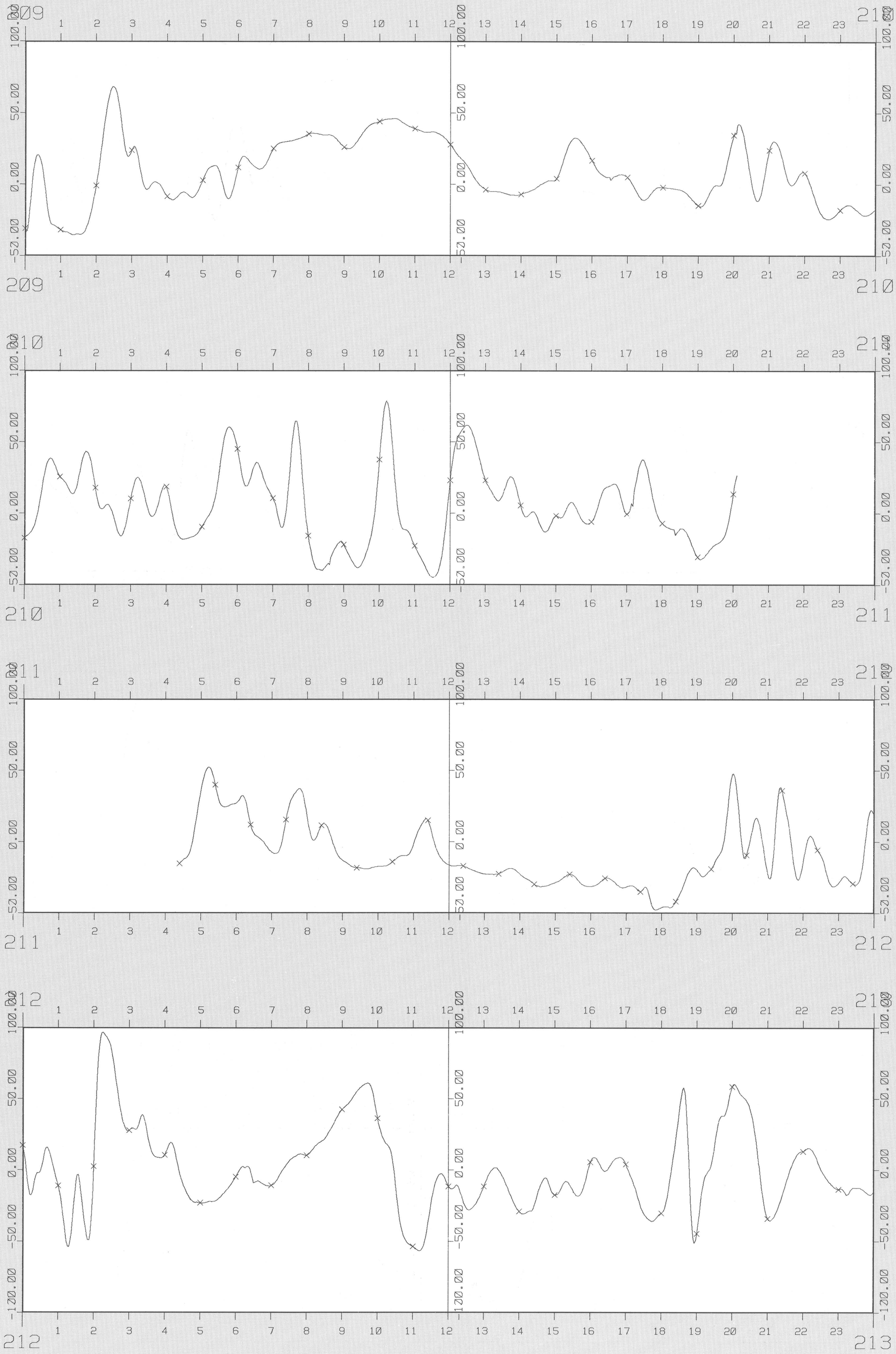






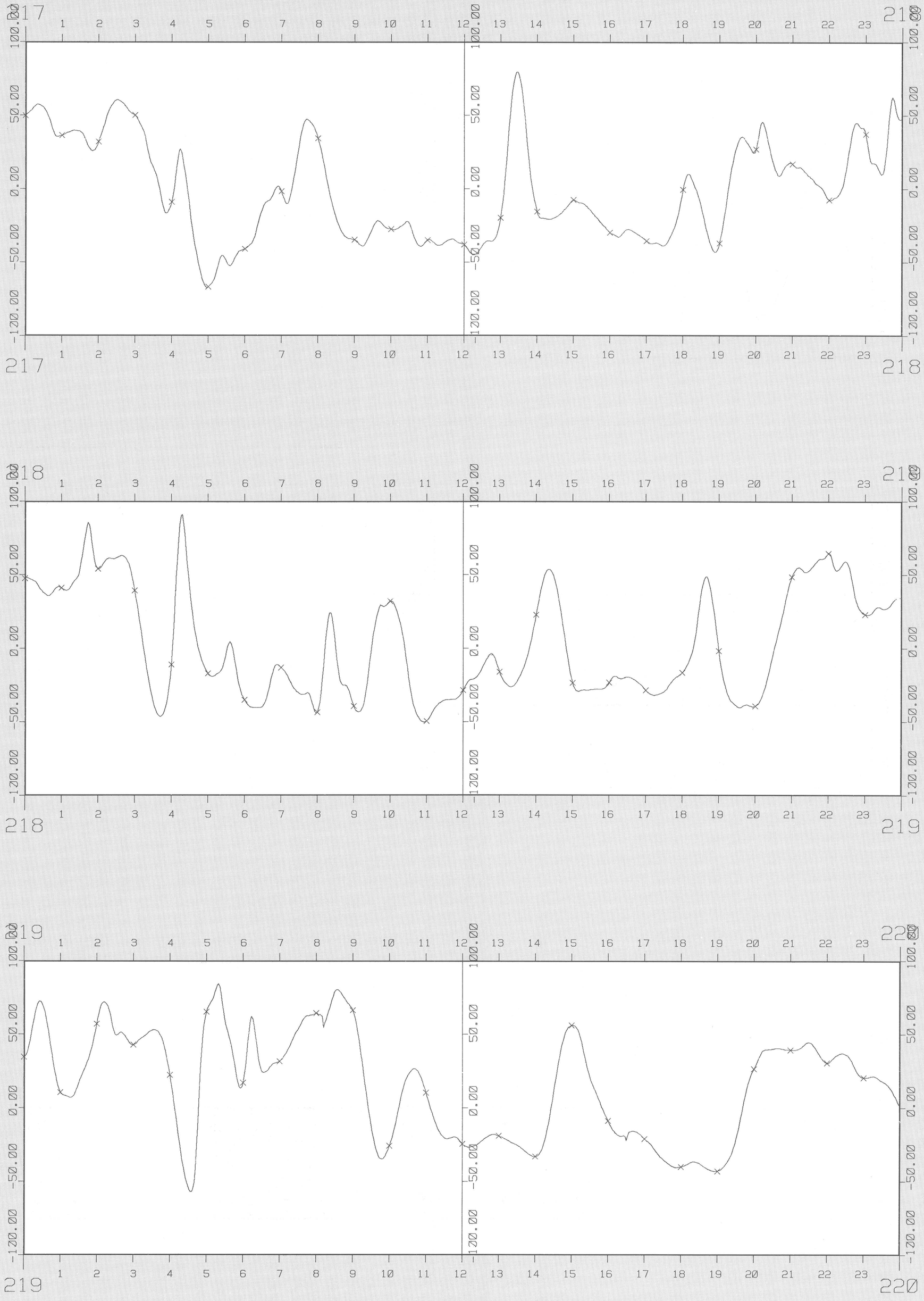
RESIDUAL MAGNETIC ANOMALY, IN GAMMAS (X 100)

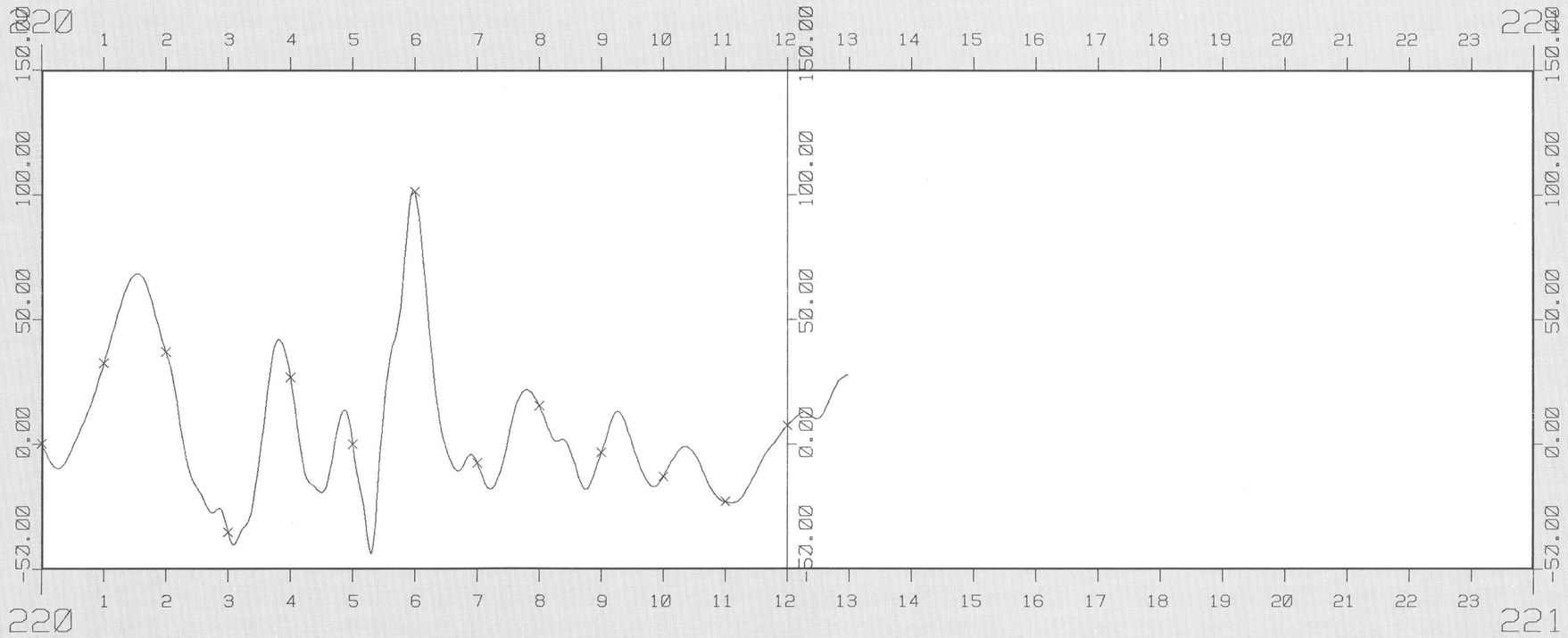
HOURS

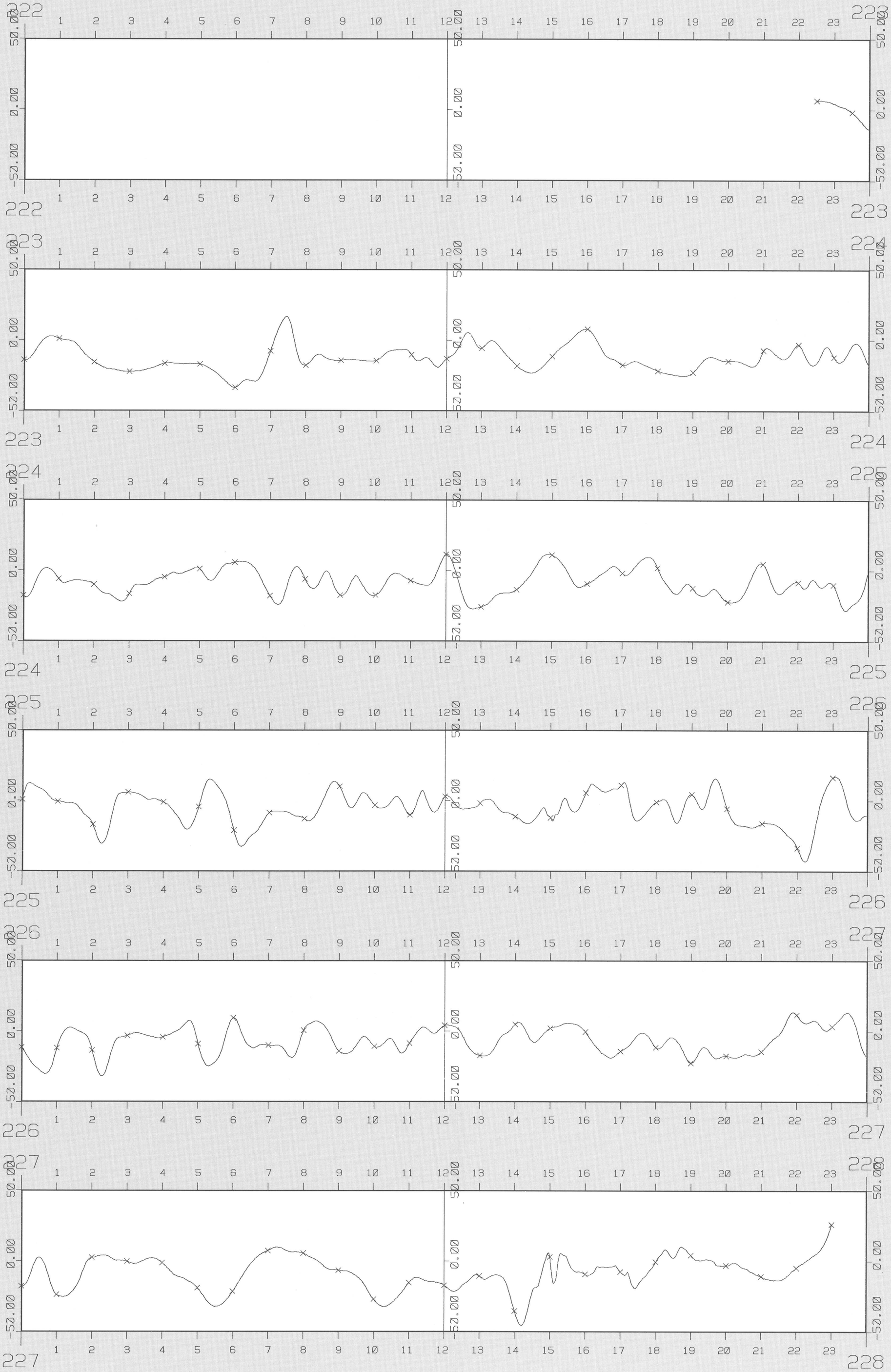

RESIDUAL MAGNETIC ANOMALY, IN GAMMAS (X 100)
209
210
211
212
213
HOURS

RESIDUAL MAGNETIC ANOMALY, IN GAMMAS (X 100)

HOURS


RESIDUAL MAGNETIC ANOMALY, IN GAMMAS (X 10)
217
218
219
220
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
100.00
50.00
0.00
-50.00
-100.00
HOURS


RESIDUAL MAGNETIC ANOMALY, IN GAMMAS (X 100)
150.00
100.00
50.00
0.00
-50.00
220
221
222
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23
HOURS


RESIDUAL MAGNETIC ANOMALY, IN GAMMAS (X 100)
50.00
0.00
-50.00
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23
222 223
223 224
224 225
225 226
226 227
227 228
HOURS