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U.S.-Soviet Collaborative Geological and Geophysical Survey of the Mid-Atlantic Ridge near 31°N
The Petrov Fracture Zone

Cruise Report

12th Cruise of the R/V Akademik Boris Petrov (Leg 1)
(February 2 - February 28, 1989)

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INTRODUCTION

In February 1989, the first formal U.S.-Soviet joint marine geologic-geophysical study in 10 years was undertaken along the Mid-Atlantic Ridge near 31°N on the 12th Cruise of the R/V Akademik Boris Petrov of the Vernadsky Institute of Geochemistry (USSR Academy of Sciences, Moscow). This survey was initiated as part of the U.S.S.R.-U.S. cooperative research project "Mid-Atlantic Ridge Crest Processes" within the framework of the Soviet-U.S. bilateral Ocean Studies Agreement (Ostenso, 1989). U.S. scientists from the U.S. Geological Survey, University of Houston, and Woods Hole Oceanographic Institution participated in this program with Soviet scientists from the Vernadsky Institute of Geochemistry, Institute of Geology, and Schmidt Institute of Physics of the Earth, all institutes of the USSR Academy of Sciences in Moscow (Appendix 1). The ship departed from Rotterdam, Nederlands on February 2, 1989 and docked in Bridgetown, Barbados on February 28, 1989. A log of the ship's schedule during this cruise is given in Appendix 2. This study involved a limited multibeam-bathymetric, gravity, magnetic, and seismic- reflection survey and dredging program of a short-offset transform fault named the Petrov Fracture Zone near 31°N, located just north of the Atlantis Fracture Zone on the Mid Atlantic Ridge (Figure 1). A site survey at King's Trough in the northeast Atlantic for a MIR submersible program in June 1989 was originally planned as part of this program, but bad weather and the resultant poor quality geophysical data forced this work to be terminated after only one day. Nearly 6000 km of geophysical profile data and 13 dredge stations were completed during this cruise. A description of the geophysical systems aboard the R/V Petrov is given in Appendices 3 and 4. All geophysical data were recorded on magnetic tape in data formats described in Appendix 5. Dredge locales and description summaries only are presented in Appendix 6. Detailed descriptions of dredge samples will be presented elsewhere. Operational plan for the studies on this cruise was developed as a cooperative effort between U.S. and Soviet scientists, who established jointly the basic objectives of the study. The U.S. scientists were given the responsibility for developing the detailed survey and dredge sampling plans. Dredge operations and basic geophysical systems operations were the responsibility of the Soviet personnel.

REGIONAL GEOTECTONIC FRAMEWORK

The region of study is along the ridge axis of the Mid-Atlantic Ridge from 30°N to 34°N between the Atlantis and Hayes Fracture Zones. For this region, the Mid-Atlantic Ridge separates the African and North American plates which are separating at a rate of 24 mm/yr to 28 mm/yr (Klitgord and Schouten, 1986). This part of the mid-ocean ridge system is classified as a slow spreading center. The survey area lies 100 km to the south of the Azores Triple Junction, where the North American, African, and European plate boundaries intersect. The Azores "hot spot" and its associated geochemical anomalies lies astride this triple junction. The plate boundary between 30°N and 34°N consists of numerous spreading-center segments offset by transform zones with various offset lengths. The Atlantis and Hayes Fracture Zones have right-lateral offsets of the ridge axis (left-lateral transform fault motion) of 60 km and 80 to 120 km respectively. The Hayes Fracture Zone is presently a double transform zone where the ridge axis, proceeding to the north, is offset first 80 km to the east and then another 40 km to the east. There are at least four shorter ridge-axis right-lateral offsets along this ridge section, including the Petrov Fracture Zone at 31°N with a 20-km offset (Figure 2), a 10-km offset near 31°45'N, a 15 to 20-km offset near 32°40'N, and a 20 to 25-km offset near 33°N. In addition, there are numerous "zero-offset" transform zones (Schouten and

Klitgord, 1982; Schouten and others, 1985) associated with minor ridge crest offsets and discontinuities. The ocean crust surveyed during this program was zero to 3.5 m.y. old, which encompasses sea-floor spreading magnetic lineations from the Central Anomaly to Anomaly 2'.

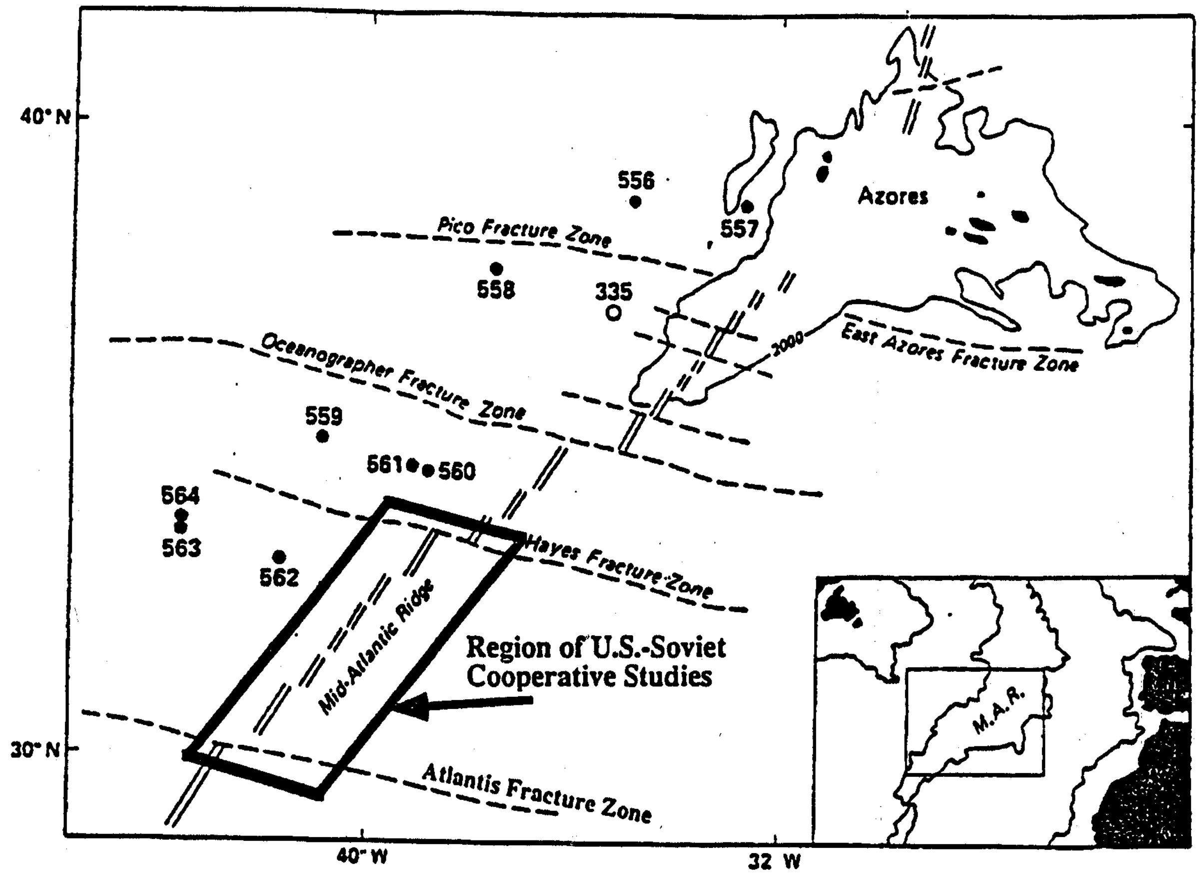

Figure 1. Generalized map of the Mid-Atlantic Ridge from the Atlantis Fracture Zone to the Azores with approximate location of R/V Petrov survey area.

SCIENTIFIC OBJECTIVES

The overall objective of the 12th cruise leg 1 of the R/V Petrov was to initiate an integrated geological sampling and geophysical surveying program on the Mid-Atlantic Ridge between the Atlantis Fracture Zone and the Hayes Fracture Zone, from 30°N to 34°N (Figure 1). The sampling and survey program was designed to address specific scientific objectives related to understanding the geological, geochemical, and geodynamic processes that help to control the generation and subsequent deformation of oceanic lithosphere. These scientific objectives are summarized as follows:

1. Establishing the morphotectonic framework of the axial Mid-Atlantic Ridge by:
   a. identifying and mapping the large-offset, small-offset, and "zero-offset" transform/fracture zones and the variability in their fault systems.
   b. identifying and mapping the axial bathymetric high, rift-valley graben, and flanking fault blocks including the segmentation characteristics of the ridge.

c. identifying and mapping magnetic lineations that provide age-isochron information and other magnetic signatures that reflect magmatic processes at the ridge.
d. identifying and mapping the gravity signatures of the ridge segments and fracture zones.

2. Establishing the magmatic contribution to oceanic crustal generation by:
a. determining of the geochemical variations along the ridge axis in young oceanic crust.
b. examining of the relationships between these variations and ridge segmentation.
c. examining of small-scale variations at large-offset, small-offset, and zero-offset transform zones.

3. Investigating the deformation of oceanic crust within transform/fracture zones by:
a. establishing the metamorphic character of mafic and ultramafic rocks, including microfabric, fluid-inclusion, and geochemical evidence.
b. establishing the deformation history of mafic and ultramafic rocks, including microfabric, fluid-inclusion, and geochemical evidence.

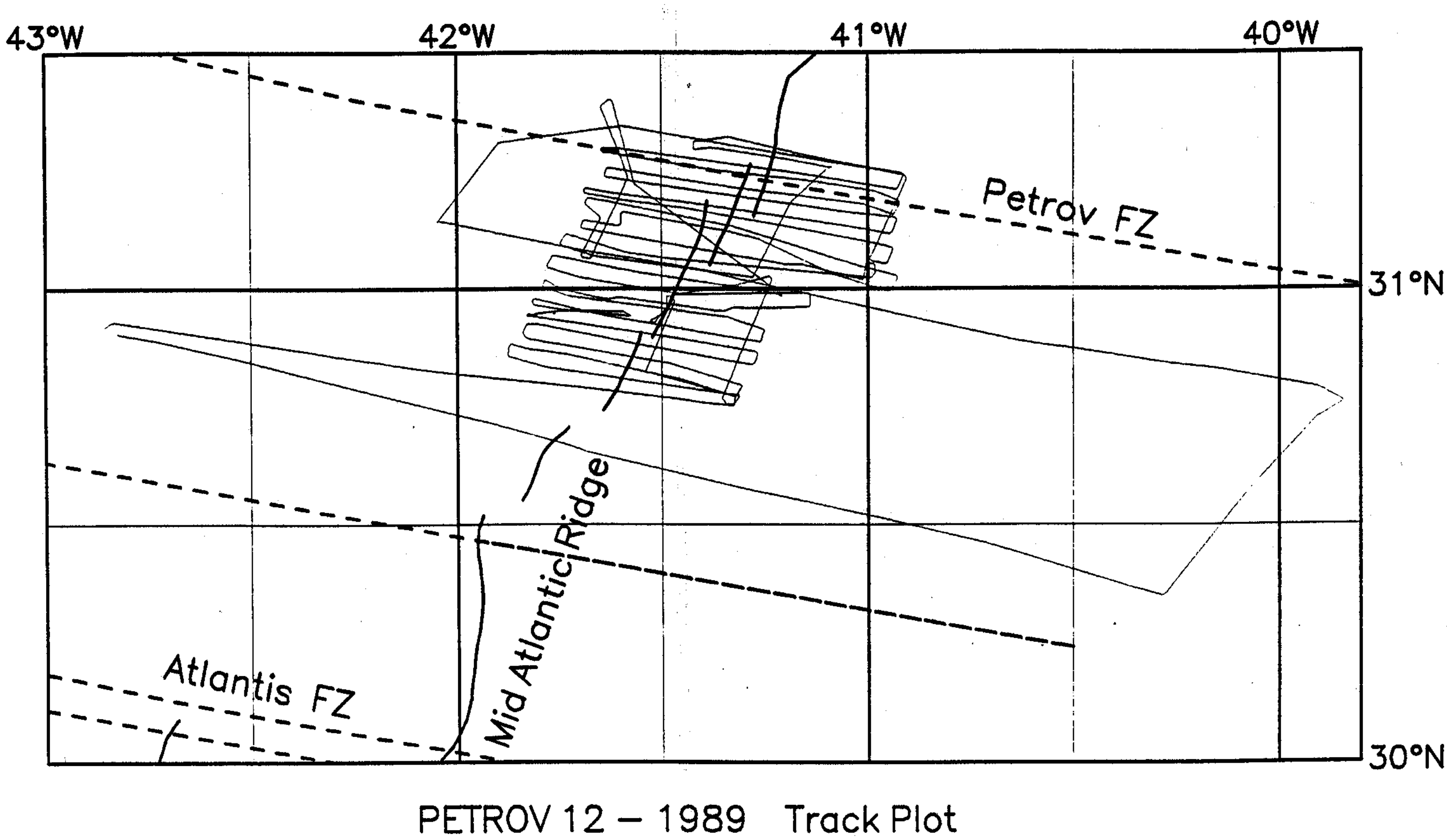

Figure 2. Track of the Petrov 12 survey of the Petrov Fracture Zone region of the Mid Atlantic Ridge near 31°N.

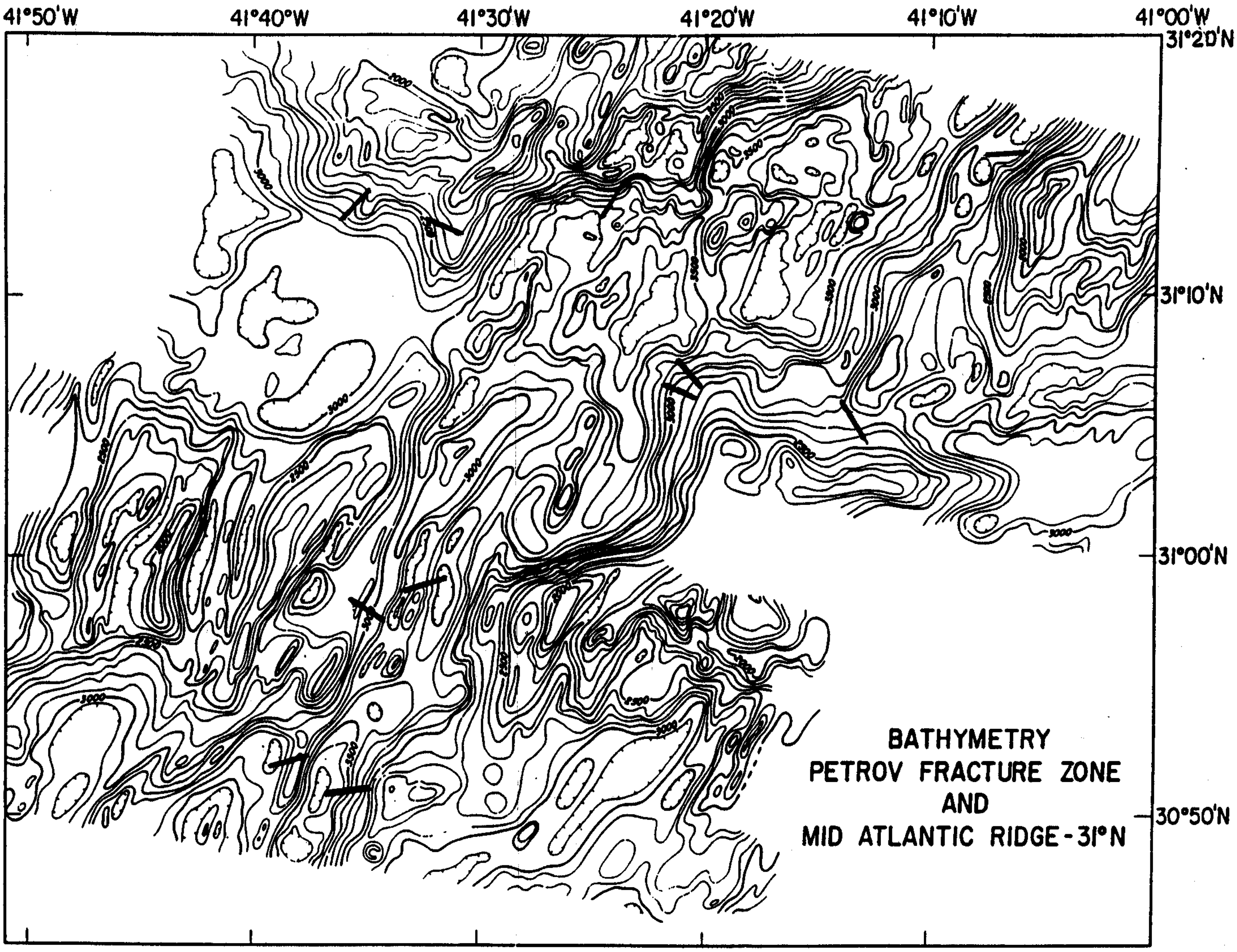

Figure 3. Bathymetric contour map of the Petrov Fracture Zone region of the Mid-Atlantic Ridge based on multibeam bathymetric mapping on this cruise. Contour interval 100m. Locations of dredge stations indicated. See Figure 3.

GEOPHYSICAL INVESTIGATIONS

Geophysical studies were undertaken using swath-mapping bathymetry, single-channel seismic-reflection, magnetic, and gravimetric systems (Dimitriev and others, 1990). We acquired nearly 6000 km of profile data. On this cruise, all of the systems were provided by the Soviets on the Petrov, and there were specialist teams for each of these systems. A summary of the geophysical systems is given in Appendices 3 and 4. One of the primary geophysical data sets acquired on this cruise was the swath-mapping bathymetry. Previous swath-mapping bathymetric surveys in the region include a detailed survey in 1988 using the R/V Conrad from the Kane to Atlantis Fracture Zones (23°N to 30°40'N) by researchers from Woods Hole Oceanographic Institution (Purdy and others, 1990) and a survey of the Hayes Fracture Zone by the Naval Oceanographic Office (Smoot, 1989). With this survey, the swath bathymetry coverage of the Mid Atlantic Ridge was extended to 31°20'N (Figure 2). Magnetic, gravity and seismic reflection data were collected on all of the survey lines in the vicinity of the Petrov FZ and on the transit to and from the Petrov FZ area.

Data Distribution

Navigation, swathmapping-bathymetric, gravimetric, and magnetic data were stored digitally on magnetic tapes, floppy disks, and removable hard disks. The navigation and bathymetry data are stored in the GF-3 format; this format is detailed in Appendix 5. The navigation data was subjected to only a preliminary editing and final navigation files were constructed at Woods Hole. The gravity information was recorded on magnetic tape and the magnetic data were recorded only on analog records. The analog magnetic data were digitized later at Woods Hole. U.S. and Soviet scientists were provided with digital copies of all these data, and copies are stored at both Houston and at the U.S. Geological Survey, Woods Hole. The seismic-reflection profiles were recorded only as analog paper records. These records were microfilmed at Woods Hole with half-scale copies at the University of Houston, U.S. Geological Survey at Woods Hole, and Vernadsky Institute. Original seismic records are stored at the Vernadsky Institute.

Swathmapping-bathymetric Survey Results:

The geophysical data acquired during this cruise enable us to characterize the morphotectonic environment of the next large fracture zone intersecting the Mid Atlantic Ridge north of the Atlantis Fracture Zone. In addition to the overlapping nodal deeps in the transform valley and the large inner corner highs at the transform-ridge intersection (Figure 3) similar to those found on other parts of the ridge system (e.g. Schouten and others, 1985), the axial valley contains a distinctive but simple structural architecture (Figure 4). The ridge segment south of the Petrov Fracture Zone is constructed of a coherent tilted block (bordering faults dipping east) in the west and a deep, sediment-filled trough in the east at the base of the primary border fault. The uptilted edge of this block forms the axial high and two small volcanoes are located along the eastern edge of this block. The axial valley segment north of the Petrov Fracture Zone has a similar asymmetric shape with a deep trough located at the base of the eastern border fault and bound by a small tilted block to the west. A small offset transform was mapped about 20 km south of the Petrov Fracture Zone, with a larger offset noted on the rift flank walls than within the axial valley.

GEOLOGICAL INVESTIGATIONS

A preliminary rock-sample dredging program was coupled with the geophysical surveys (see Figure 4 for dredge localities). A summary of the dredge sites and samples acquired at these sites is given in Appendix 6. More detailed descriptions of the rock samples from each dredge site will be presented elsewhere. Eleven dredge stations were located near the Petrov Fracture Zone/Mid Atlantic Ridge intersection and one each at the Oceanographer and Hayes Fracture Zones. The dredge sites were split between the two major objectives of looking at geochemical variations along the ridge axis and examining the deformation of crustal rocks within transform zones. J.F. Casey was primarily responsible for the ridge axis sampling program. S. Silantiev were responsible for the fracture zone sampling program. Seven (7) dredge sites were focused on the rift valley axial-high, zero-age crust investigation and six (6) dredges were placed within transform-fault, fracture-zone locales. Most of the dredges within the rift valley recovered fresh glass on near-zero age crust. All of the rocks recovered from these ridge axis sites were of basaltic origin, including aphyric as well as plagioclase and olivine phyric samples. All dredges in the Petrov Fracture Zone have yielded only basaltic samples and most of the samples from the Hayes FZ were dolerites. In contrast, suites of basaltic, gabbroic, and ultramafic rocks were recovered by dredging within Oceanographer Transform Zone. A brief description of these samples is given in Appendix 6.

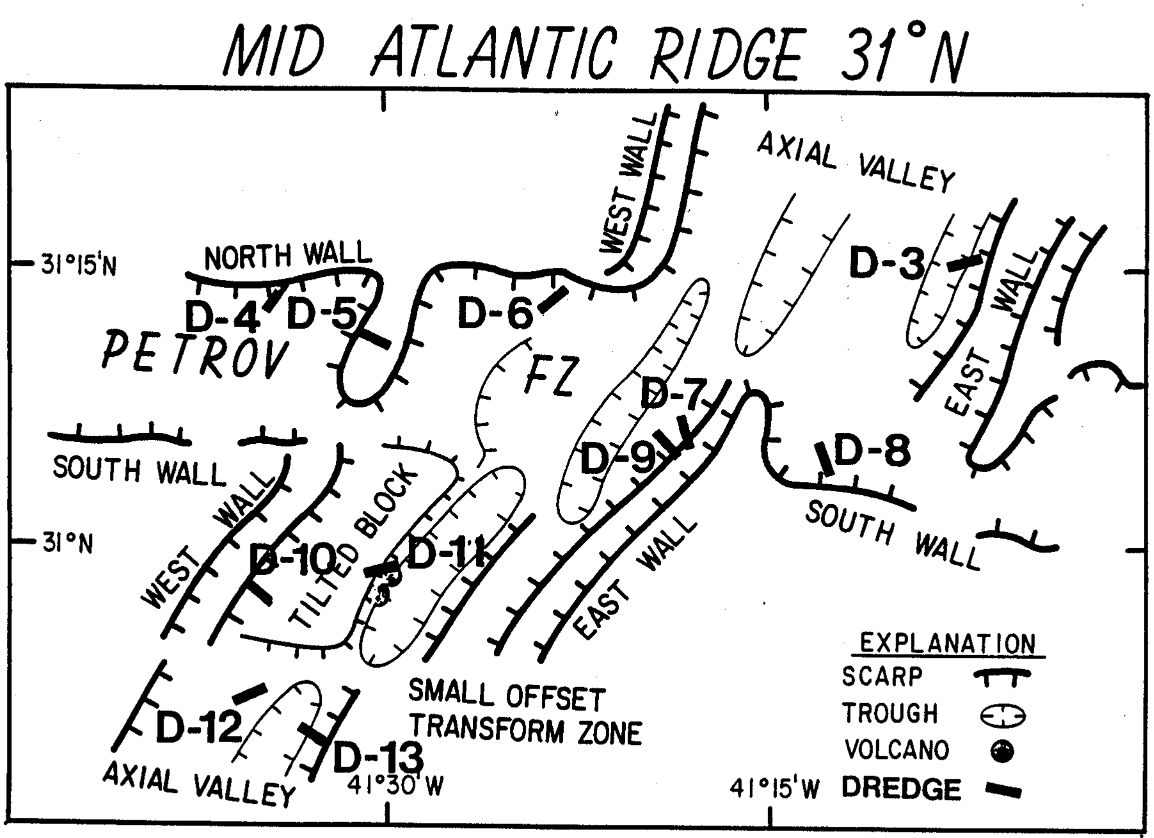

Figure 4. Dredge stations occupied during the 1989 survey of the Mid-Atlantic Ridge from 30°N to 34°N during Cruise 12 (Leg 1) of the R/V Akademik Boris Petrov.

Sample Distribution

The rock collection acquired on this cruise is to be housed at the Vernadsky Institute of Geochemistry in Moscow and at the Department of Geosciences, University of Houston, Houston, with approximately half of the rock samples located at each place. All of the sedimentary samples were sent to the University of Houston. The U.S. scientists were responsible for the sample curation, including initial rock descriptions, cataloging, labelling, and distribution. Final shipboard rock descriptions and sample splitting were based on mutual agreement between U.S. and Soviet scientists. Representative rock samples from each dredge locale were selected for cutting slabs and making thin sections onboard. Many rock samples were split, with the U.S. and Soviet groups each taking half. This split was agreed upon to enable us to divide the shore-based analytical work and to provide samples upon which the same analyses could be carried out for calibration of systems and techniques. The rock samples were generally divided into two roughly equal collections for the Soviet and U.S. scientists where there was abundant material available in individual dredges. In cases where there was a sparse amount of material in individual dredges, many of the samples were cut in half so that each side could have a representative sampling of each dredge haul. All of the samples are to be subjected to systematic chemical analyses in both Moscow and the U.S., including whole-rock major element, trace element, and isotopic analyses of basaltic and plutonic rocks and microprobe and ion-probe studies on glasses, minerals, and melt inclusions. Thin sections were made of many of the samples on board the ship. These samples are indicated in Appendix 6. A complete set of these thin sections was sent back to Moscow, and a small subset of duplicate thin sections was taken to the University of Houston and the Woods Hole Oceanographic Institution. Additional thin sections are being made at these three institutions for more detailed analytic studies.

Dredge Results:

Eleven dredges were conducted in a localized region within the Petrov Fracture Zone and the adjacent ridge segments (Figure 3). Petrologic studies of these samples show a distinctive geochemical anomaly associated with this transform fault (Casey and others, 1990). The geochemical trends observed from ridge segments to the transform domains are also noted to be opposite of those trends that have been previously proposed to result from the "transform-fault effect" (Bender and others, 1984). A single dredge in the Hayes Fracture Zone also showed a similar type of geochemical signature relative to the adjacent ridge segments, with depletions in incompatible elements and certain distinctive elemental ratios (e.g., Ce/Yb) thought not to undergo significant changes during closed system fractional crystallization. These geochemical signatures suggested that further studies in the area between 30°N and 34°N may be key in understanding the nature of short-wavelength geochemical variations along zero-age crust of slow-spreading ridge segments and the association of geochemical changes with long- and short-offset transform faults as well as other small-scale axial discontinuities.

SUMMARY

Despite a short amount of time available for on-site investigations (10 days), a comprehensive geophysical survey and rock sampling program was successfully undertaken of part of the midocean ridge system in the central Atlantic. This study of the Petrov Fracture Zone and adjacent segments of the Mid Atlantic Ridge demonstrated the similarity in general morphotectonic and petrologic character with other sections of the Mid Atlantic Ridge, but more importantly it identified a major difference in trends of petrologic variations across a fracture zone. In addition, the survey provided the detailed structural character within the axial valley needed to examine the interplay between magmatic and tectonic processes at spreading centers.

Acknowlegements

We gratefully acknowledge logistical support of T. Aldrich and T. O'Brien and reviews by W.Dillon and C.Schneider.

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APPENDIX 1

SCIENTIFIC PERSONNEL

1. Dr. Leonid Dmitriev - Soviet co-chief scientist
   Vernadsky Institute of Geochemistry, Moscow, Russia
2. Dr. Kim D. Klitgord - U.S. co-chief scientist
   U.S. Geological Survey, Woods Hole, MA 02543 USA
3. Dr. John F. Casey - petrologist
   University of Houston, Houston TX USA
4. Mr. Kevin Johnson - petrologist
   MIT - WHOI joint program, Woods Hole, MA USA
5. Prof. Vladimir Tulin - gravity specialist
   Institute of Physics of the Earth, Mosow, Russia
6. Dr. Sergei Silantiev - metamorphic petrologist
   Vernadsky Institute of Geochemistry, Moscow, Russia
7. Sergei Zahpunny, Expedition secretary, fascilitator
   Vernadsky Institute of Geochemistry, Moscow, Russia
8. Ruben Magakyan - petrologist - chief of dredge operations
   Vernadsky Institute of Geochemistry, Moscow, Russia
9. Mikhail Reisner, computer expert
   Vernadsky Institute of Geochemistry, Moscow, Russia
10. Matalia Kononkova, petrologist and watch stander
    Institute of Geology, Moscow, Russia
11. Dr. Vladimir v. Mayorshin - magnetic specialist
    Institute of Terrestrial Magnetism - Troizk, Moscow, Russia
12. Mikhail Zakharov - multibeam bathymetry specialist
    Institute of Geology, Moscow, Russia
13. Vadim Golod - seismic specialist
    Institute of Geology, Moscow, Russia
14. Boris Bazylev - ultramafic petrologist; dredge operations team
    Vernadsky Institute of Geochemistry, Moscow, Russia
15. Lyudmila Polosina - thin-section lab operations
    Vernadsky Institute of Geochemistry, Moscow, Russia
16. Olga Tsameryan - petrologist; multibeam bathymetry watch
    Vernadsky Institute of Geochemistry, Moscow, Russia

Ship's captain: Mr. Rein Kasak

APPENDIX 2

Ship's Log For Cruise 12 (Leg 1) of R/V Akademik Boris Petrov

02/02/89	2100h	Depart Rotterdam	Foul weather in the English Channel
02/03/89	1200h	Transit to Kings Trough	Stormy weather
02/04/89	1200h	Transit to Kings Trough	Stormy weather
02/05/89	1200h	Transit to Kings Trough	Stormy weather
02/06/89	1200h	Transit to Kings Trough	Stormy weather
02/07/89	1030GMT	Kings Trough-west end	Start swath bathy., gravity & seismic survey
02/08/89	1830GMT	Kings Trough-west end	Terminate surveys. Bad weather. Heading south.
02/09/89	0000GMT	Transit to Oceanog. FZ	No profiling because of lack of permits in Azores
02/10/89	1200h	Transit to Oceanog. FZ	Weather improving
02/10/89	1800GMT	Survey along Anom. 5 west	Swath-bathy., magnetic, gravity & seismic prof.
02/11/89	0600GMT	Arrive at Oceanog. FZ	small survey parallel to and across FZ
02/11/89	1800GMT	Oceanographer FZ	pulling in profiling gear preparing for dredge sta.
02/12/89	0200GMT	Dredge PD-12-1	start dredge station north wall Oceanog. FZ
02/12/89	1000GMT	Dredge PD-12-1	end dredge station
02/12/89	1200GMT	Survey south to Hayes FZ	along anom 5 west
02/13/89	0800GMT	Dredge PD-12-2	at Hayes FZ. Gear pulled in and starting dredge
02/13/89	1400GMT	Dredge PD-12-2	end dredge station. North wall Hayes FZ
02/13/89	1600GMT	Survey south to MAR 31N	Seismic, magnetic, gravity & swath-bathy prof.
02/14/89	1200GMT	Survey of MAR 31N region	poor weather. poor swath bathy data.
02/15/89	1200GMT	Survey of MAR 31N region	weather better. swath bathy data not much better
02/16/89	1200GMT	Survey of MAR 31N region	swath bathy not better. chg balast fwd on ship.
02/17/89	1400GMT	Dredge PD-12-3	pull gear and start dredge station.
02/17/89	1800GMT	Dredge PD-12-3	end dredge. east wall MAR north of Petrov FZ
02/17/89	2000GMT	Survey of MAR 31N region	seismic, magnetic, gravity & swath-bathy prof.
02/18/89	1700GMT	Dredge PD-12-4	pull gear and start dredge station.
02/18/89	2100GMT	Dredge PD-12-4	end dredge. northwest wall Petrov FZ (31.2N)
02/18/89	2200GMT	Dredge PD-12-5	start dredge station. 10 km east of PD-12-4
02/19/89	0500GMT	Dredge PD-12-5	end dredge. northwest wall Petrov FZ
02/19/89	0600GMT	Dredge PD-12-6	start dredge station. 20 km east pf PD-12-5
02/19/89	1000GMT	Dredge PD-12-6	end dredge. northwest wall Petrov FZ
02/19/89	1200GMT	Dredge PD-12-7	start dredge. SE intersection MAR-Petrov FZ
02/19/89	1700GMT	Dredge PD-12-7	dredge lost. (inner corner high)
02/19/89	2200GMT	Dredge PD-12-8	start dredge station. southeast wall Petrov FZ.
02/20/89	0100GMT	Dredge PD-12-8	end dredge. south of MAR median valley.
02/20/89	0400GMT	Dredge PD-12-9	start dredge. SE intersection MAR-Petrov FZ.
02/20/89	0800GMT	Dredge PD-12-9	end dredge. (inner corner high) near PD-12-7.
02/20/89	1000GMT	Survey of MAR 31N region	seismic, magnetic, gravity & swath-bathy prof.
02/20/89	0000GMT		pull gear.
02/21/89	0100GMT	Dredge PD-12-10	start dredge station. Outer west wall MAR
02/21/89	0600GMT	Dredge PD-12-10	end dredge. 1st ridge segment south of Petrov FZ
02/21/89	0700GMT	Survey of MAR 31N region	seismic, magnetic, gravity & swath-bathy prof.
02/22/89	0100GMT		pull gear.
02/22/89	0200GMT	Dredge PD-12-11	start dredge. Inner west wall MAR
02/22/89	0600GMT	Dredge PD-12-11	end dredge. 1st ridge segment south of Petrov FZ
02/22/89	0800GMT	Dredge PD-12-12	start dredge. MAR axial high. 2nd ridge segment
02/22/89	1100GMT	Dredge PD-12-12	end dredge. south of Petrov FZ.

02/22/89	1200GMT	Dredge PD-12-13	start dredge. MAR east wall. 2nd ridge segment
02/22/89	1600GMT	Dredge PD-12-13	end dredge. south of Petrov FZ.
02/22/89	1700GMT	Survey of MAR 31N region	seismic, magnetic, gravity & swath-bathy prof. west to anom 5 and then south to Atlantis FZ.
02/23/89	0600GMT	Atlantis FZ	continue survey west 10 km and then south again.
02/23/89	1200GMT	Transit along anom 5 west	continue geophys. profiling. Heading to Barbados.
02/24/89	1200GMT	Transit along anom 5 west	continue geophysical profiling.
02/24/89	2200GMT	Kane FZ	change course straight for Barbados.
02/24/89	1200GMT	Transit to Barbados	continue geophysical profiling.
02/27/89	1700GMT	crossing Baracuda Ridge	end profiling.
02/28/89	0700h	Arrive in Barbados	end of cruise.

APPENDIX 3

GEOPHYSICAL MEASUREMENT AND GEOLOGIC SAMPLING SYSTEMS

The geophysical systems on the ship were all provided by the Soviets. The bathymetric swath-mapping system and transit satellite navigation systems are standard equipment on the RV Petrov. The magnetometer and gravity systems were provided by the other institutions of the Russian Academy of Sciences for this cruise.

1. **Multibeam bathymetric mapping system**
   a. ECHOS 625 model 4630 built in Finland by Hollming Ltd.
   probably based on U.S. Seabeam system
   b. operator - Natalya Turko, Institute of Geology
   assistant - Yecaterina Pavlenko, Institute of Geology
   c. 15 beams with 4.3 degree (across axis) and 2.5 degree (along axis) dimensions
   d. 12 kHz frequency with 1, 3, or 10 ms pulse lengths
   e. operating depths of 100m to 4000+m
   f. swath coverage = 40 degrees = 70% water depth
   g. real-time swath, strip plotting using 10" Benson strip plotter
   h. data logging in main computer with GF-3 format
   i. ETAC bathymetry system (12k Hz) for single-beam data and analog display
   j. see Appendix 4 for more details

2. **Gravity system**
   a. 4-AMG double quartz resilient torsion meter systems (LaCoste Romberg type systems) on gyro platforms; 2 parallel sensors in each unit.
   b. 2- forward-directed and 2 aft-directed beams for calc. cross coupling correction
   c. developed and build at USSR Academy of Sciences Institute of Physics of the Earth.
   d. operator: Dr. Vladimir Tulin, Inst. Physics of the Earth
   assistant: ?, Inst. Physics of the Earth
   e. 3 sec. recording, 10 Hz filter; with 5 min. avg. using 3rd degree spline smoothing filter.
   all four meters recorded on tape.
   f. sensitivity = 0.2 mgal
   g. range of measurements without readjustment = 8-12 Gal.
   h. error of scale coefficient = ~ (3-4) E-04
   i. preliminary estimate of error = 1.3-2.0 mgal; systematic error < 4 mgal.
   j. recorded on 800bpi 9-T tape with EC9004.01 PC-XT computer built in Hungary

3. **Magnetometer system**
   a. optical-pumped Cesium magnetometer
   b. built at USSR Academy of Sciences Institute of Terrestrial Magnetism, Moscow
   c. operator: Vladimir Mayorshin, Inst. of Terrestrial magnetism
   d. 180m towing cable
   e. 10 sec. sampling rate
   f. hand digitized at 5 minute interval; redigitized at Woods Hole with < 1 min. interval.
   working to get digital logging, but there was limited access to main computer logging facility

4. **Navigation system**
   a. Magnavox MX5400 Global Positioning System (GPS) satellite receiver
   no digital link to NAVOS - 625 system until Dec. 1990.

b. Magnavox Transit Satellite positioning system
c. NAVOS - 625 integrated navigation system
with ship's gyro, speed log, and satellite system plus Loran-C where possible
d. digital recording in main computer system (EC-1011)

5. Single-Channel Seismic-Reflection Profiling System

a. Source: modified BOLT-type airgun
air volume = 0.5 liter; air pressure = 100 kg/sq.cm.
2 guns built at the Institute of Geology
b. Receiver: single-channel streamer with 50 hydrophone elements per 30m
total length = 50m
c. Recorder: RAYTHEON LSR-1807M dry paper
stylus scan = 2 sec./scan, 1 stylus
paper feed = 120 (150) lines/inch
memory sweep = 4 sec/scan, left-right
d. operator: Mikhail Zakharov, Institute of Geology

6. Deep-Sea Winch and Barrel Dredge Rock Sampling System

a. 10 tonne Hagglunds deep-sea winch
w/series 84 type 84-25100 high-torque hydraulic motor
b. large barrel dredge - approx. 1m x 1.5m

7. Water chemistry and physical oceanography system

a. CARMAC water sampling system
b. Salinometer system
c. CTD measuring and logging system
d. Ion analyzer

APPENDIX 4

MULTIBEAM BATHYMETRIC SWATH-MAPPING SYSTEM
ECHOS-625 MODEL 4630

Builder: Hollming Ltd., Finland, 1984
Ships: RV A. Boris Petrov, RV A. Nikolaj Strakhov, and RV A. M.A. Lavrentyev

Receiving Subsystem:

SONAR CHARACTERISTICS	Frequency	12 kHz
	Pulse Length	1, 3, or 10 ms
	Transmitting Interval	10 sec.
	Power	200W or 2 kW
	Sounding Depth	100m - 4000+m
	Bottom Width coverage	40 deg.,70% w.d.
ARRAY DESIGN	**Transmitting Array**	
	Length	1620 mm
	Number of Projectors	12 x 1
	Beam Dimensions	64 deg. x 4.3 deg.
	Receiving Array	
	Length	3456 mm
	Number of Hydrophones	36 x 3 (108)
	Beam Dimensions	2.5 deg. x 60 deg.
FORMED BEAMS	**Digital Beam forming**	
	Number of Beams	15
	Beam Dimensions	2.5 deg. x 4.3 deg.
	Beam Spacing	3 deg.
	Analog Beam forming	
	Number of Beams	1
	Beam Dimensions	9.2 deg. x 4.3 deg.

Processing Subsystem:

ANALOG BEAM
- Echograph recording of the analog beamformer generated echo pulses (non-compensated vertical beam)
- Digitizer digital display of the depth on the non-compensated vertical beam
- Acoustic Device listening of the underwater sound pulses

NARROW BEAM
- Line Scan Recorder recording of echo pulses from any of the 15 digitally-formed narrow beams (pitch and roll corrected).

MULTI-BEAM
- Vertical Reference based digital pitch and roll angle compensation
- Navigation system generated time (GMT), position (LAT,LON), ship (SPD,HDNG), and line (DA,DC,DE) information included.
- Color Video Monitor display of the bottom profile. Numerical data display or graphical 3-dimensional display can be selected. Graphical beam data display off-line option available.

. Magnetic tape transport recording of raw pulse data or final echo-sounding data. Repeating possibility from magnetic tape.

REAL TIME DATA LOGGING

. Logging Computer logging and storage of analog beam and multi-beam echo-sounding data into standard formatted (GF-3) data logging files

. Processing Computer equipotential depth curve generation on the flat-bed plotter.

. Local Area Network access to the Logging Computer State Table holding the latest echo-sounding and other environmental data.

APPENDIX 5

FORMATS FOR DIGITAL DATA

1. **Navigation Data**

a. in GF3 format = "NS" format

CYCLE PARAMETERS:		FORMAT	
1) NARE2N1N	NAVIGATION REPORT TYPE	I2	(6=SAT.FIX)
2) DATE5N1N	DAY, D	A4	
3) TIME5N1N	TIME, H,MIN,S	A6	
4) LATD5N1N	SYSTEM LATITUDE, DEG	I4	
5) LATM5N1N	SYSTEM LATITUDE, MIN	F6.3	
6) LOND5N1N	SYSTEM LONGITUDE, DEG	I4	
7) LONM5N1N	SYSTEM LONGITUDE, MIN	F6.3	
8) LATD5N2N	RAW NAV LATITUDE, DEG	I4	
9) LATM5N2N	RAW NAV LATITUDE, MIN	F6.3	
10) LOND5N2N	RAW NAV LONGITUDE, DEG	I4	
11) LONM5N2N	RAW NAV LONGITUDE, MIN	F6.3	
12) LATD5N3N	FIX LATITUDE, DEG	I4	
13) LATM5N3N	FIX LATITUDE, MIN	F6.3	
14) LOND5N3N	FIX LONGITUDE, DEG	I4	
15) LONM5N3N	FIX LONGITUDE, MIN	F6.3	
16) LATD5N4N	NEW LATITUDE, DEG	I4	
17) LATM5N4N	NEW LATITUDE, MIN	F6.3	
18) LOND5N4N	NEW LONGITUDE, DEG	I4	
19) LONM5N4N	NEW LONGITUDE, MIN	F6.3	
20) LATD5N5N	OLD LATITUDE, DE	I4	
21) LATM5N5N	OLD LATITUDE, MIN	F6.3	
22) LOND5N5N	OLD LONGITUDE, DEG	I4	
23) LONM5N5N	OLD LONGITUDE, MIN	F6.3	
24) SSPD2N1X	SYSTEM SPEED, KN	F4.1	
25) DIRT5N1N	SYSTEM HEADING, DEG	F6.1	
26) DRSP2N1N	DRIFT SPEED, KN	F4.1	
27) DIRT5N2N	DRIFT HEADING, DEG	F6.1	
28) LINA2N1N	LINE NAME, -	A8	
29) DIST2N1N	DIST ALNG LINE FR START, KM	F8.3	
30) DIST2N2N	DISTANCE ACROSS LINE, KM	F8.3	
31) DIST2N3N	DIST ALNG LINE TO END, KM	F8.3	
32) DIRT5N3N	GYRO HEADING, DEG	F6.1	
33) DELT2N1N	DELTA X, M	I6	
34) DELT2N2N	DELTA Y, M	I6	
35) DELT2N3N	DELTA Z, M	I6	
36) ECCN2N1N	RECIPROCAL OF FLATTENING, -	I6	
37) SMAX2N1N	SEMIMAJOR AXIS, M	I6	
38) STDV2N1N	FIX LATIT STAND DEV, M	I4	
39) STDV2N2N	FIX LONGIT STAND DEV, M	I4	
40) LITY2N1N	LINE TYPE, CODE	I2	
41) DATF2N1N	DATUM FLAG, CODE	I2	
42) STDV2N3N	SYST LAT NEW STAND DEV, M	I4	

43)	STDV2N4N	SYST LONG NEW STAND DEV, M	I4
44)	STDV2N5N	SYST LAT OLD STAND DEV, M	I4
45)	STDV2N6N	SYST LONG OLD STAND DEV, M	I4
46)	CAUP2N1N	CAUSE TO UPDATE, CODE	I2
47)	SHNU2N1N	SHOT NUMBER, -	I4
48)	MINS5N1N	TIME SINCE LAST FIX, MIN	I4
49)	WATR2N1N	DISTANCE IN WATER TRACK, NM	I4
50)	SPTY2N1N	SPEED TYPE, CODE	I2
51)	HETY2N1N	HEADING TYPE, CODE	I2
52)	RADF2N1N	RAD NAV USE FLAG, -	I2

2\. **Multibeam Bathymetric Data**

a. in GF3 format = "MB" format

CYCLE PARAMETERS:		FORMAT	
1)	DATE5B1N	SOUNDING DATE, D	A4
2)	TIME5B1N	SOUNDING TIME, H,MIN,S	A6
3)	LATD5B1N	SYSTEM LATITUDE, DEG	I4
4)	LATM5B1N	SYSTEM LATITUDE, MIN	F6.3
5)	LOND5B1N	SYSTEM LONGITUDE, DEG	I4
6)	LONM5B1N	SYSTEM LONGITUDE, MIN	F6.3
7)	SSPD2B1N	SYSTEM SPEED, KN	F4.1
8)	DIRT5B1N	SYSTEM HEADING, DEG	F6.1
9)	DIST2B1N	DIST ALNG LINE FR START, KM	F8.3
10)	DIST2B2N	DISTANCE ACROSS LINE, KM	F8.3
11)	DIST2B3N	DIST ALNG LINE TO END, KM	F8.3
12)	DIST2B4N	DIST FROM START POINT, KM	F8.3
13)	DEPH5B1D	BEAM 1 DEPTH, M	I4
14)	DEPH5B2D	BEAM 2 DEPTH, M	I4
15)	DEPH5B3D	BEAM 3 DEPTH, M	I4
16)	DEPH5B4D	BEAM 4 DEPTH, M	I4
17)	DEPH5B5D	BEAM 5 DEPTH, M	I4
18)	DEPH5B6D	BEAM 6 DEPTH, M	I4
19)	DEPH5B7D	BEAM 7 DEPTH, M	I4
20)	DEPH5B8D	BEAM 8 DEPTH, M	I4
21)	DEPH5B9D	BEAM 9 DEPTH, M	I4
22)	DEPH5BAD	BEAM 10 DEPTH, M	I4
23)	DEPH5BBD	BEAM 11 DEPTH, M	I4
24)	DEPH5BCD	BEAM 12 DEPTH, M	I4
25)	DEPH5BDD	BEAM 13 DEPTH, M	I4
26)	DEPH5BED	BEAM 14 DEPTH, M	I4
27)	DEPH5BFD	BEAM 15 DEPTH, M	I4
28)	DIST2B5N	B1 DIST FROM CENTRAL LINE,M	I5
29)	DIST2B6N	B2 DIST FROM CENTRAL LINE,M	I5
30)	DIST2B7N	B3 DIST FROM CENTRAL LINE,M	I5
31)	DIST2B8N	B4 DIST FROM CENTRAL LINE,M	I5
32)	DIST2B9N	B5 DIST FROM CENTRAL LINE,M	I5
33)	DIST2BAN	B6 DIST FROM CENTRAL LINE,M	I5
34)	DIST2BBN	B7 DIST FROM CENTRAL LINE,M	I5
35)	DIST2BCN	B8 DIST FROM CENTRAL LINE,M	I5
36)	DIST2BDN	B9 DIST FROM CENTRAL LINE,M	I5

37) DIST2BEN	B10 DIST FR CENTRAL LINE, M	I5
38) DIST2BFN	B11 DIST FR CENTRAL LINE, M	I5
39) DIST2BGN	B12 DIST FR CENTRAL LINE, M	I5
40) DIST2BHN	B13 DIST FR CENTRAL LINE, M	I5
41) DIST2BIN	B14 DIST FR CENTRAL LINE, M	I5
42) DIST2BJN	B15 DIST FR CENTRAL LINE, M	I5
43) SVEL2B1D	SOUND VELOCITY, M/S	F6.1
44) PITC2B1N	PITCHING ANGLE, DEG	F4.1
45) ROLL2B1N	ROLLING ANGLE, DEG	F4.1

Note: The GF3 data format is one of the standardized international formats for storage and distribution of geophysical data. A detailed description of this format is found in the GF3 report by the Intergovernmental Oceanographic Commission (1987).

APPENDIX 6

RV AKADEMIK BORIS PETROV-12 (ABP-12) DREDGE STATIONS

Station number:	**PD-12-1**
Date:	12 Feb 1989
Lat/Long:	35° 18.1'n 35° 59.7'w to 35° 23.0'n 35° 55.7'w
Water depth:	3780m to 2400m
Sampling device:	large barrel dredge (1 meter x 1.5m)
Number of samples:	27 rock samples samples split between U.S. and Soviet scientists
Weight (kg):	100 kg
Type of samples:	ultramafics (90%), metagabbro & basaltoids (1%) Fe-Mn crusts & limestones (7-8%)
Remarks:	dredge up the north wall (south-facing) of Oceanographer FZ near west end of active transform zone at 10 my old crust (SFS anom 5)

Station number:	**PD-12-2**
Date:	13 Feb 1989
Lat/Long:	33° 39.3'n 38° 35.4'w to 33° 43.3'n 38° 33.3'w
Water depth:	4000m to 2400m
Sampling device:	large barrel dredge (1 meter x 1.5m)
Number of samples:	9 rock samples samples split between U.S. and Soviet scientists
Weight (kg):	20 kg
Type of samples:	dolerites (90%), hyaloclastites (5%) Fe-Mn crusts & limestones (4%) deep sea muds (1%)
Remarks:	dredge up the north wall (south-facing) of Hayes Fracture Zone within active transform zone.

Station number:	**PD-12-3**
Date:	17 Feb 1989
Lat/Long:	31° 15.5'n 41° 05.4'w to 31° 15.4'n 31° 08.6'w
Water depth:	3084m to 3161m
Sampling device:	large barrel dredge (1 meter x 1.5m)
Number of samples:	3 rock samples
Weight (kg):	50 kg
Type of samples:	deep sea muds (98%) pillow basalts (1-2%), chilled glass fragments (1%)
Remarks:	dredge near base of eastern wall of MAR just north of Petrov FZ

Station number: **PD-12-4**
Date: 18 Feb 1989
Lat/Long: 31° 11.5'n 41° 35.1'w to 31° 13.0'n 41° 33.7'w
Water depth: 2798m to 2590m
Sampling device: large barrel dredge (1 meter x 1.5m)
Number of samples: 4 rock samples
Weight (kg): 1000 kg
Type of samples: pillow basalts and hyaloclastites (20-30%)
deep sea muds (70-80%)
Remarks: dredge up the northwest wall (south-facing) of Petrov FZ
near west end of active transform zone.
included one very large pillow about 2' diameter
that was gradually broken up for smaller samples.

Station number: **PD-12-5**
Date: 18 Feb 1989
Lat/Long: 31° 12.6'n 41° 31.4'w to 31° 12.3'n 41° 30.4'w
Water depth: 2600m to 2160m
Sampling device: large barrel dredge (1 meter x 1.5m)
Number of samples: 7 rock samples
Weight (kg): 20 kg
Type of samples: pillow basalts (15%), fragments of chilled glass (10%)
hyaloclastites, limestone and deep-sea muds (75%)
Remarks: dredge up the northwest wall (south-facing) of Petrov FZ
over ridge that protrudes southward from wall.
To west of active transform.

Station number: **PD-12-6**
Date: 19 Feb 1989
Lat/Long: 31° 13.6'n 41° 24.4'w to 31° 14.2'n 41° 23.0'w
Water depth: 2875m to 2360m
Sampling device: large barrel dredge (1 meter x 1.5m)
Number of samples: 14 rock samples
Weight (kg): 1500 kg
Type of samples: pillow basalts, chilled glass fragments, and hyaloclastites (90%)
deep-sea muds (10%)
Remarks: dredge up the north wall (south-facing) of Petrov FZ near intersection
with western border fault of the ridge segment north of fz.
within the active transform part of fz.
included one very large pillow about 1-m diameter

Station number: **PD-12-7**
Date: 19 Feb 1989
Lat/Long: 3°o 08.6'n 41° 20.3'w to 31° 08.0'n 41° 19.5'w
Remarks: dredge caught on bottom and lost

Station number:	**PD-12-8**
Date:	20 Feb 1989
Lat/Long:	31° 05.8'n 41° 12.2'w to 31° 04.6'n 41° 14.5'w
Water depth:	2900m to 2600m
Sampling device:	large barrel dredge (1 meter x 1.5m)
Number of samples:	7 rock samples
Weight (kg):	50 kg
Type of samples:	pillow basalts(95%), fragments of chilled glass (2%) deep-sea muds (3%)
Remarks:	dredge up the southeast wall (north-facing) of Petrov FZ near the eastern edge of the active transform zone.

Station number:	**PD-12-9**
Date:	20 Feb 1989
Lat/Long:	31° 08.6'n 41° 20.3'w to 31° 08.0'n 41° 19.5'w
Remarks:	dredge caught on bottom but recovered - no samples

Station number:	**PD-12-10**
Date:	20 Feb 1989
Lat/Long:	30° 56.8'n 41° 34.4'w to 30° 56.9'n 41° 34.8'w
Water depth:	3156m to 2850m
Sampling device:	large barrel dredge (1 meter x 1.5m)
Number of samples:	8 rock samples
Weight (kg):	250 kg
Type of samples:	pillow basalt (95%), deep-sea muds (5%)
Remarks:	dredge up the western edge of rift segment just south of Petrov FZ. On western border scarp.

Station number:	**PD-12-11**
Date:	21 Feb 1989
Lat/Long:	30° 58.6'n 41° 29.2'w to 30° 56.9'n 41° 34.8'w
Water depth:	3450m to 3200m
Sampling device:	large barrel dredge (1 meter x 1.5m)
Number of samples:	8 rock samples
Weight (kg):	300 kg
Type of samples:	pillow basalts (100%)
Remarks:	dredge up the east-facing scarp within center of the ridge segment just south of the Petrov FZ. Near a small volcano on the eastern edge of tilted block.

Station number:	**PD-12-12**
Date:	22 Feb 1989
Lat/Long:	30° 53.1'n 41° 34.8'w to 30° 52.3'n 41° 36.8'w
Water depth:	3558m to 3100m
Sampling device:	large barrel dredge (1 meter x 1.5m)
Number of samples:	4 rock samples
Weight (kg):	40 kg
Type of samples:	pillow basalts (100%)
Remarks:	dredge up axial high near small-offset transform between first and second rift segment south of Petrov FZ. Near zero age crust.

Station number:	**PD-12-13**
Date:	22 Feb 1989
Lat/Long:	30° 51.2'n 41° 32.8'w to 30° 55.3'n 41° 32.8'w
Water depth:	2970m to 2700m
Sampling device:	large barrel dredge (1 meter x 1.5m)
Number of samples:	1 rock sample
Weight (kg):	1 kg
Type of samples:	fragments of chilled glass (100%)
Remarks:	dredge up the eastern border fault of second ridge segment south of the Petrov FZ.