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Report on DELP 1985 Cruises in the Japan Sea Part I: General Outline

JAPANESE DELP RESEARCH GROUP ON BACK-ARC BASINS

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Abstract

In the summer of 1985, as a part of the Japanese Development and Dynamics of Lithosphere Program (DELP), geophysical and geological research cruise (DELP-85 WAKASHIO cruise) was made in the Yamato Basin and the Japan Basin of the Japan Sea. These basins are believed to have been formed as a result of back-arc spreading during a short period of time (15-21Ma) and their crust show an intermediate character between continental and normal oceanic crusts. There were other cruises for similar program closely related to the present survey and run by several institutions, *i.e.* Geological Survey of Japan, Ocean Research Institute (Univ. Tokyo) as well as Japan Marine Science and Technology Center in the fiscal years 1985 and 1986.

This report describes mainly the results of the research DELP-85 WAKASHIO cruise in the Yamato and Japan Basin. Some of the results still remain in a preliminary stage of analysis. Data and interpretations obtained by other cruises related to the resent program are also referred to in this report. The ship used for this cruise was the WAKASHIO-MARU chartered from the Nippon Salvage Co. Ltd. Scientists from six universities and the Geological Survey of Japan participated in the program. The scientific objectives, surveyed area, cruise periods, terms of observation, filing of data base, name of participants and areas covered by other cruises related to the present program are listed below. Some results obtained prior to the present survey are also included in the concluding discussion (8. Main Results) of this part.

1. Scientific objective

Evolution and structure of a back-arc basin, the Japan Sea, and its bearing on tectonic history of Japanese Islands.

It is claimed by paleomagnetic studies of rocks from the Japanese Islands as well as Korea that the Japanese Islands were a part of the Asian continent and departed from it about 20 Ma B.P. (OTOFUJI *et. al.*, 1986) leaving a wide basin area, the Japan Sea, behind. Three major

cases of distinctive topographic features of the Japan Sea are the Yamato Rise of continental structure, the Yamato Basin to the south of the Yamato Rise and the Japan Basin which is to the northeast of the Yamato Rise and much deeper than the Yamato Basin. There is no indication of active ridge volcanism in these basins in spite of distribution of young dispersed buried volcano shaped highs. Magnetic anomaly patterns are irregular and their linear trends are not clearly defined. Seismic deep structures of the Yamato Basin seems to be characterized by a mixture of continental and oceanic crusts and it has been thought that in the Yamato Basin there exists anisotropy of the seismic wave velocity in the azimuthal orientation as revealed by sea to land observations (OKADA *et. al.*, 1978).

The large scale structure of the Yamato Basin is considered to show characteristic features similar to that of the Japan Basin and the northern part of the Shikoku Basin, *i.e.* a greater depth than that expected from the depth versus age relations for oceanic basins, Early to Middle Miocene age of opening, dispersed but relatively high average heat flow and existence of many isolated small seamounts. However, much of the detailed fine structures and the depth of Moho discontinuity of the Yamato Basin have not been clarified yet. It is not well understood either what kind of geometrical as well as mechanical relationships exist between the Yamato Basin and the northern side of the Japanese landmass adjacent to the Basin.

Therefore, the Yamato Basin was chosen for the present study to meet the requirement of the stated scientific objective.

2. Area surveyed and related cruises

The area surveyed by the present DELP-85 WAKASHIO cruise is shown in Fig. I-1. Underway geomagnetic and topographic surveys were also carried out on the steaming tracks from port to survey area and on its way back. Areas of some other cruises closely related to DELP-85 are also shown. Detailed track lines of the present cruise are given in Fig. I-2.

3. Cruise period

Cruise; DELP-85 WAKASHIO (Wakashio-Maru)

Leg I

July 15 Dept. from Niigata.
16 Multichannel seismic profiling, line A.
17 Multichannel seismic profiling, line B.

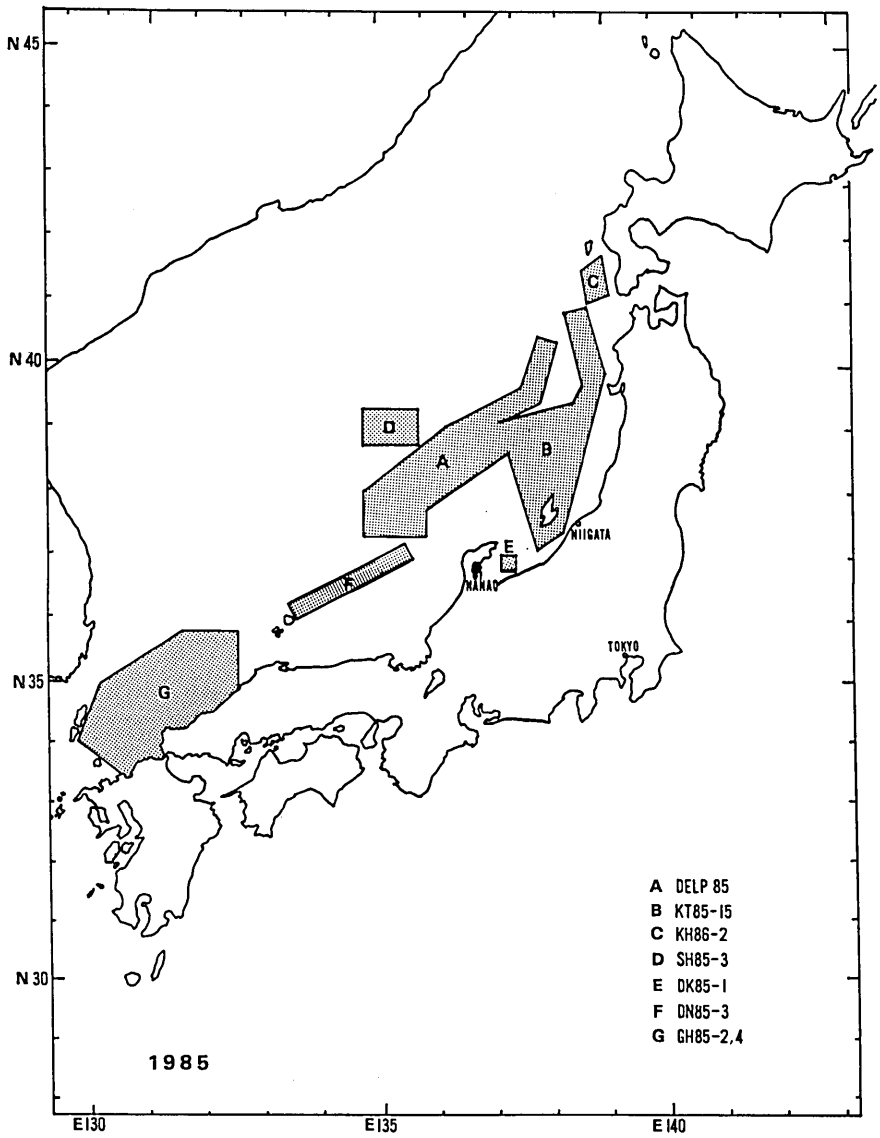

Fig. I-1. A sketch map of survey areas in the Japan Sea run by various institutions and project groups in fiscal years 1985 and 1986. Alphabetical labels A through G represent:

A DELP-85 by Wakashio-Maru
B KT85-15 by Tansei-Maru, ORI
C KH86-2 by Hakuho-Maru, ORI
D SH85-3 by Shinkai 2000, JAMSTEC
E DK85-1 by Kaiyo, JAPEX/JAMSTEC
F DN85-3 by Natsushima, JAMSTEC
G GH85-2 and 4 by Hakurei-Maru, GSJ

ORI : Ocean Research Institute, University of Tokyo
JAMSTEC: Japan Marine Science and Technology Center
JAPEX : Japan Petroleum Exploration Corporation
GSJ : Geological Survey of Japan

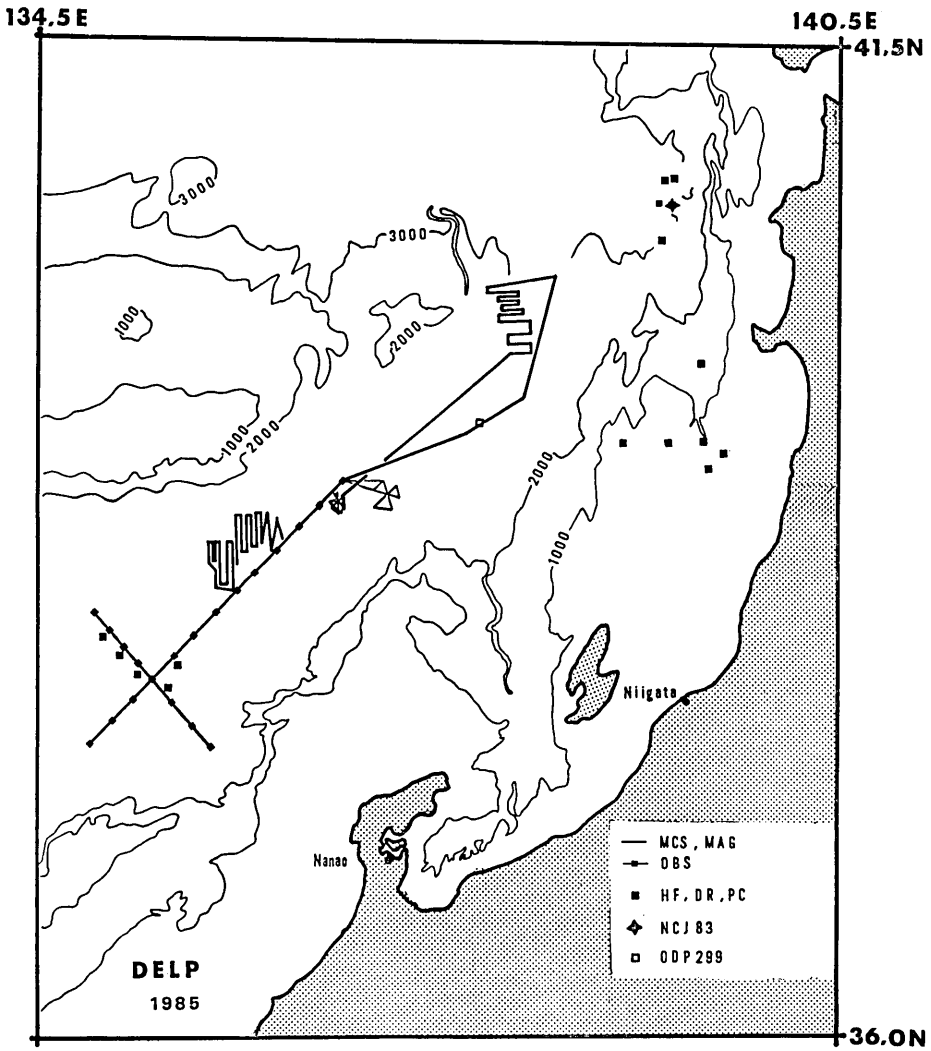

Fig. I-2. Survey lines and stations of DELP-85 WAKASHIO cruise in the Japan Sea by the Japanese DELP Research Group on Back-Arc Basins.
Symbols denote:
MCS : Survey lines for multichannel seismic profiling
MAG: Survey lines for 3-axis and total force magnetometry
OBS : Stations for ocean bottom seismometry
HF, DR, PC: Stations for heat flow, dredge haul and piston coring
NCJ83; Epicenter of an earthquake in 1983
ODP299; Deep Sea Drilling Project, Site 299

17-19 Deployment of OBS's (ocean bottom seismometers).
19-22 Explosive and airgun shooting, lines A and B.
23 Multichannel seismic profiling for proposed ODP Site.
24 Magnetic survey.

25-27 Recovery of all OBS's.
27 Magnetic survey.
28 Arriv. at Nanao.

Leg II
July 29 Dept. from Nanao.
30-Aug. 2 Heat flow, dredge haul, magnetic survey.
Aug. 2 Arriv. at Niigata.

4. Items of observation

1. 12 kHz precision depth recording
2. 3.5 kHz depth recording
3. Multichannel (6-ch.) seismic profiling
4. Ocean bottom seismometer (20 sets)
   4-1. Structure
   4-2. Seismicity
5. Geomagnetic survey
   5-1. Total force
   5-2. Three-axis vector component
6. Heat flow
7. Dredge haul

5. Data filing and processing

1. Track positioning
2. Depth record (digitized) for whole track lines
3. Shot instance of large volume airgun
4. Shot instance of explosions
5. Geomagnetic elements (Hx, Hy, Hz and F)
6. Seismic wave form (digitized)

6. Participants

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7. Other related Cruises in the Japan Sea for the fiscal years 1985 and 1986

1) Geological Survey of Japan by R/V Hakurei-Maru.
Gravity, geomagnetism, deep tow (hydrophone), seismic profiling, dredge haul, piston coring, and side scanning image profiling.
2) Japan Marine Science and Technology Center by R/V Natsushima and Submersible Shinkai 2000.
Geology of Yamato Rise.
3) Same institution by R/V Natsushima.
Sonar and camera.
4) Same institution by R/V Kaiyo.
Deep tow subsurface sonar and camera, and Seabeam.
5) Ocean Research Institute by R/V Hakuho-Maru (ODP[4)] related).
Geomagnetism, multichannel seismic profiling, conductivity anomaly, heat flow, dredge haul, piston coring, and GPS test.
6) Same Institution by R/V Tansei-Maru (DELP and ODP related).
Geomagnetism, heat flow, dredge haul, ocean bottom seismometry, and multichannel seismic profiling.

8. Main results

The main results of the DELP-85 WAKASHIO and other cruises are described below. Further details of the study, references and original data are described in the individual sections of this report.

1) Seismic refraction study in the Yamato Basin area revealed that

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[4)] ODP; Ocean Drilling Program.

the crustal structure of this area is neither of a continental nor a normal oceanic character. Velocity structure is given as (tentative Model P): 2.2, 4.2, 5.3, 6.7–7.0 and 8.0–8.1 km/sec, respectively, in a descending order from the top of the crust. Subsurface depth of Moho interface is about 18 km. Anisotropy of the upper mantle velocity is confirmed and NNW-SSE is as high as 5 percent compared to ENE-WSW.

2) The topmost part of the crust is characterized by a steep gradient in P-wave velocity (in the subsurface depths of 5–8 km).

3) A seismic 3.5 km/sec layer which has been considered to be Green Tuff layer and is assumed to appear ubiquitously in the Japan Sea could hardly be observed in the Yamato Basin.

4) Seismic profiling revealed six identifiable acoustic layers of which the lowermost acoustic unit seems idenfical to Paleogene Green Tuff widely distributed in the Japanese Main Island.

5) Seismic profiles revealed from the structure of buried faults in acoustic basement and overlying sediment cover that the horizontal stress field of the basin in the middle Tertiary (20–15 Ma) was extensional. However, deformation of sediment cover shows that the present stress field is compressional. This feature is compatible with the thrust mechanism of the 1983 Nihonkai-Chubu Earthquake of Magnitude 7.7 (determined by Japan Meteorological Agency).

6) Heat flow values of the Yamato Basin average to ca. 100 mW/m^2 which corresponds to 25 Ma lithospheric age based upon the cooling plate model.

7) On the eastern flank of the Japan Basin where a new subduction seem to be in the incipient stage, the heat flow value amounts to as high as 250 mW/m^2 which is extremely high compared to the average value. There are some indications of dispersion of bright colored sea floor materials as well as an image of outburst of some buoyant materials or a side echo from a small hill on the 3.5 kHz depth recording profilers.

8) Two lines of buried seamount and knoll chains running NE-SW parallel to each other in the Yamato Basin seem to have been formed by volcanic activities of 6–15 Ma possibly related to the opening of the Yamato Basin. The southern line of topographic highs composes a ridge like feature as a whole and we name it "Yamato Basin Ridge". Pillow basalts dredged from the Yamato Basin Ridge consist of augite and plagioclase in its main composition and are of marginal basin basalt (MBB). They give a minimum age of the formation as 7.3 Ma which is to be compared with 6–17 Ma (KANEOKA *et al.*, 1986) from the northern seamount chain of the Basin.

9) Tentative tectonic history of the Japan Sea is reconstructed on the basis of the present report combined with some other additional data.

Age (Ma)	Formation	Horizontal stress field
0– 5	Sedimentation and compressional deformation of the depositional materials.	Compressional
5–15	Yamato Basin Ridge system formed.	Extensional
15–20	Drift of the Japanese landmass from eastern edge of the Asian mass. Opening of the Yamato Basin?	Extensional? (paleomagnetic data)

Acknowledgements

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DELP 1985 年度日本海研究航海報告

I. 全体計画

DELP 背弧海盆研究班

1985 年度を中心とする日本海海底探査研究航海のうち，DELP 研究グループが主催ないしは関連した部分について得られた固体地球科学的成果について述べる．日本海の中で大和海盆と日本海盆は主要部分を占める．これら海盆の成因・年代・構造については主として，Back-arc spreading の機構で説明されるものと考えられてきた．今回の総合的研究によって日本海生成の古環境についてより詳細な知見が得られ，日本海の拡大は複雑な過程を経て行われ，海といえどもかなりの部分に陸的性質の混在を許している事が分かってきた．