Active source seismic studies across/along across-arc seamount chains in Izu-Bonin arc - Cruise report of KR0601 and KR0605 -

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Abstract In order to investigate formation processes of the across-arc sea mount chains in the Izu-Bonin arc, we have carried out two active source seismic cruises by using JAMSTEC R/V Kairei in 2006. The wide-angle seismic data were acquired across the across-arc seamount chains (Nishi-shichito ridge) in KR0605 and along the across-arc seamount chain (Minami-Iojima ridge) in KR0601. In addition to those two wide-angle profiles, multichannel seismic data were also acquired along two profiles which are parallel to the strike of the across arc seamount chains. The wide-angle seismic data indicate thinning of crust toward the south across the Nishi-shichito ridge, and relatively flat and thin crust beneath the Minami-Ioujima ridge. The multichannel data show that the basement of the Shikoku basin can be traced beneath the western flank of the across-arc seamount chain. This suggest that a boundary between the Shikoku basin crust and the Oligocene Izu arc may be situated around the eastern end of the across-arc seamount chains.

Keywords: Crustal structure, active source seismic study, Izu-Bonin, across-arc seamount chains

1. Introduction

The Izu-Bonin-Mariana (IBM) intra-oceanic arc system extends over 2800 km from Sagami Bay in the north to Guam in the south, and has long been studied as an excellent example of an intra-oceanic island arc system. The tectonic history of the IBM arc is well documented in many studies. Here, we briefly summarize those studies of relevance to ours, following the work of Stern et al. (2003). Estimates of the age of basement rocks of the IBM forearc (Bloomer et al., 1995; Cosca et al., 1998) suggest that initial subsidence of the lithosphere along the IBM arc began at about 50 Ma. Depleted tholeiites and boninites erupted at the forearc at this stage (Hickey and Frey, 1982; Stern et al., 1991; Taylor et al., 1994). Subsidence of the lithosphere evolved into subduction at about 43 Ma (Eocene) when the motion of the Pacific plate changed abruptly from a northerly to a westerly direction (Richards and Lithgow-Bertellone., 1996).

The magmatic arc was close to its present position at the commencement of subduction (i.e., the distance from the magmatic arc to the trench has changed little since the formation of the magmatic arc). Single-arc volcanism continued until rifting started along the Parece Vela Basin at 30 Ma (Oligocene). At 25 Ma, the Shikoku basin started spreading at the northernmost end of the IBM arc and propagated to the south (Kobayashi et al., 1995; Okino et al., 1999). The two rifting systems met at 20 Ma, and spreading stopped at about 15 Ma. The Kyushu-Palau Ridge (KPR) was formed at the western edge of both basins. At the same time (15 Ma) the development of a subduction zone at the Nankai Trough initiated the collision of the northernmost part of the Izu arc with the central Japanese landmass. Back arc rifting along the Mariana Trough started at 10 Ma, and the consequent seafloor spreading began at 3–4 Ma (Bibee et al., 1980; Yamazaki and Stern, 1997). Intra-arc rifting west of the present-day volcanic front of the Izu arc started at 2 Ma.

In the rear arc side of the Izu-Bonin arc, across-arc seamount chains are observed. Volcanism began along the across-arc seamount chains and at adjacent isolated seamounts at ca. 17 Ma, slightly before the Shikoku Basin ceased spreading, and continued until ca. 3 Ma (Ishizuka et al. 1998; 2003). Volcanism along these chains occurred sporadically along their total length, although volcanoes in the western part of the chains ceased to erupt earlier than those to the east. Volcanism

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along the seamount chains ceased at the initiation of rifting behind the volcanic front at ca. 2.8 Ma (Ishizuka et al. 2002).

Remarkable geochemical variations along the across-arc seamount chains have been observed (e.g., Hochstaedter et al., 2000). These across-arc variations imply that: 1) the proportion of slab-derived fluid component becomes smaller toward the backarc; 2) fluid is the dominant slab-derived component in the volcanic front, while sediment melt becomes more significant in the rear-arc seamounts; 3) heterogeneity exists in the mantle wedge prior to the addition of slab-derived components; 4) decompression melting may predominate toward the rear-arc whereas flux melting may predominate toward the volcanic front, even without backarc spreading; and 5) felsic magmatism inherits these differences. A more enriched source, in terms of the less-fluid-mobile incompatible elements, is expected to underlie the across-arc seamount chains. It is unknown whether these patterns occur uniformly across the arc or only along the across-arc seamount chains – that is, whether slab-derived components add continental-type crust only in certain parts of the arc. In order to examine formation mechanism of the across-arc seamount chains and their geochemical variations, we carried out two active source seismic cruises along and across the across-arc sea mount chains in 2006.

2. Experiments

2.1 KR0601

Wide-angle seismic data were acquired along the Minami-Ioujima ridge, which is located at the southern end of Izu-Bonin arc, by using a seismic system on R/V Kairei (Fig. 1). The cruise was from 5th to 27th of January. We deployed Ocean bottom seismographs (OBS) from 7th to 13^{t}h. Air-gun shooting was done from 14th to 17th. OBSs were recovered from 17th to 22nd. One OBS (Site 12) was not recovered. Acoustic transponder seemed to work, but due to unknown reason this OBS did not released. After recovering the OBS, air-gun shooting test with a flip-flop mode was done. Although we planned to acquired multichannel reflection seismic data in adjacent profiles, those profile have not been made due to bad sea condition in the beginning of the cruise (Table 1 and 2). This cruise was the first R/V Kairei's wide-angle seismic experiment using more than 100 OBSs.

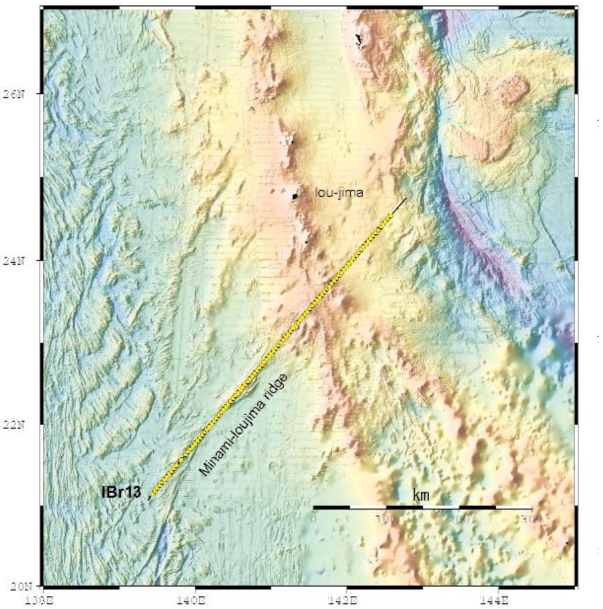

Figure 1: Profile map of KR0601

Table 1: Daily log of KR0601 cruise.

Date	Remarks
1/5	Departure from Jamstec
1/6	Transit
1/7	OBS Deployment (Site 100 – 91)
1/8	OBS Deployment (Site 90 – 71)
1/9	OBS Deployment (Site 70 – 48)
1/10	OBS Deployment (Site 47 – 30)
1/11	OBS Deployment (Site 29 – 19), Standby from 11:00
1/12	OBS Deployment (Site 18 – 10), Standby from 17:00
1/13	OBS Deployment (Site 9 – 1), Standby from 15:00
1/14	8:00, Deployment air-gun, 11:30, Start shooting IBr13
1/15	Shooting IBr13
1/16	Shooting IBr13
1/17	4:00 Stop shooting, end of IBr13, 7:00 OBS Retrieval (Site 100 – 92)
1/18	OBS Retrieval (Site 91 – 69)
1/19	OBS Retrieval (Site 68 – 48)
1/20	OBS Retrieval (Site 47 – 31)
1/21	OBS Retrieval (Site 30 – 19), Recovery drifting OBS (Site 14)
1/22	OBS Retrieval (Site 18 – 1), Site 2 was not recovered.
1/23	Flip-flop shooting test, 11:00 Retry Site 2, not recovered.
1/24	Retry Site 2, not recovered.
1/25	Transit
1/26	Transit
1/27	Arrival at Jamstec

Table 2: Profile positions of KR0601

Line ID	Date	Time	Position		SP
		(JST)	Lat (N)	Lon (E)	
IBr13	2006/1/14	11:35:33	21°04'24.274"N	139°22'35.378"E	996
	2006/1/17	03:53:19	24°45'25.355"N	142°47'04.719"E	3682

2.2 KR0605

Wide-angle seismic data across the Nishi-shichito ridge between 27º N and 32º N and multichannel reflection data along two profiles from the Kinan seamount chain to the western edge of the Nishi-shichito ridge were acquired during this cruise (15 th of May to 6 the of June) (Fig. 2, Table 3 and 4). OBSs were deployed from 16th to 21st. Air-gun was shot for the OBSs to acquired the wide-angle seismic data from 21st to 25th. All OBSs were recovered from 26th to 31st. An acoustic transponder mounted on an OBS (Site22) did not respond, but it came up to sea surface without any reply. The multichannel reflection data were acquired from 1st to 4th of June. Sea condition was very stable during the entire period of this cruise. A new type of an acoustic transponder (System-Giken) is used in this cruise. It is attached to 27 OBSs. The new system, which is directory controlled by the ship-board acoustic system, worked fine except "inactive" command. The "inactive" command to stop replying seemed to be automatically reset sometime after this command was accepted.

3. Seismic systems

3.1 Air-gun array

An air-gun array equipped on R/V Kairei was used for all profiles during the cruise. Shooting interval was 50 m, corresponding 20 – 30 s with accuracy of shot time of 1 ms for acquiring multichannel reflection data, while 200 m for acquiring wide-angle seismic data. Total volume of the air-gun array we used was 12,000 cubic inches, which consists of eight Bolt long life air-gun with 1,500 cubic inches each. The standard air pressure was 2000 psi (140 MPa). As shown in Fig. 3, two string of sub-array were deployed at the port and starboard sides of the vessel. Their width was expaned to 88.0 m by paravane system and the central position of the array was set 197.0 m behind the ship GPS antenna position.

3.2 Ocean bottom seismograph

For recoding the wide-angle seismic data, we deployed 100 OBSs with 5 km interval during both cruise (Table 5 and 6), and recovered all of them except

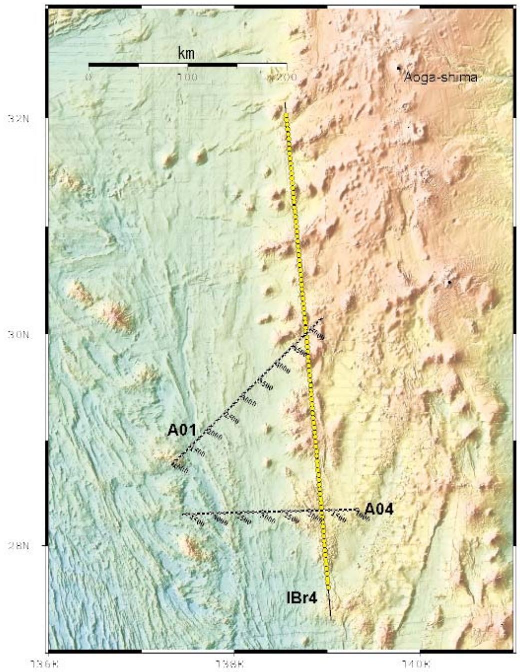

Figure 2: Profile map of KR0605

Table 3: Daily log of KR0605

Date	Remarks
5/15	Departure from Yokosuka-Shinkou port
5/16	OBS Deployment (Site 1 – 10)
5/17	OBS Deployment (Site 11 – 30)
5/18	OBS Deployment (Site 31 – 48)
5/19	OBS Deployment (Site 49 – 70)
5/20	OBS Deployment (Site 71 – 90)
5/21	OBS Deployment (Site 91 – 100), 19:00 Start shooting IBr4
5/22	Shooting IBr4
5/23	Shooting IBr4
5/24	Shooting IBr4
5/25	3:00 Stop shooting, end of profile, 12:00 OBS Retrieval (Site 1 – 9)
5/26	OBS Retrieval (Site 10 – 23), Site22 did not respond
5/27	OBS Retrieval (Site 100 – 93)
5/28	OBS Retrieval (Site 92 – 74)
5/29	OBS Retrieval (Site 73 – 52)
5/30	OBS Retrieval (Site 51 – 34)
5/31	OBS Retrieval (Site 33 – 24), Retry Site22, recovered
6/1	7:00 Deployment ari-gun, 15:10 Start shooting A04
6/2	17:00 Stop shooting, end of A01, 23:00 Start shooting A01
6/3	Air-gun shooting
6/4	6:30 Stop shooting, end of A01,
6/5	Transit
6/6	Arrival at Harumi port

Table 4: Profile positions of KR0605

Line ID	Date	Time	Position		SP
		(JST)	Lat (N)	Lon (E)	
IBr13	2006/1/14	11:35:33	21°04'24.274"N	139°22'35.378"E	996
	2006/1/17	03:53:19	24°45'25.355"N	142°47'04.719"E	3682

Table 5: OBS positions of KR0601

SITE	Deployment				Retrieval				OBS Position		
	Time UTC	Position Lat(N)	Lon(E)	Depth	Time UTC	Position Lat(N)	Lon(E)	Depth	Lat(N)	Lon(E)	Depth
1	2006/01/13 05:48	21_08.9045	139_26.6058	4944	2006/01/22 11:30	21_08.8553	139_26.4980	4951	21_08.8794	139_26.4299	4946.9
2	2006/01/13 04:25	21_10.9643	139_28.4810	4877	2006/01/22 09:39	21_10.9577	139_28.4098	4951	21_10.9587	139_28.3043	4982.3
3	2006/01/13 03:04	21 13.0180	139 30.3091	4938	2006/01/22 08:01	21 12.9825	139 30.2038	4951	21 12.9624	139 30.1046	4972.4
4	2006/01/13 01:44	21 15.1106	139 32.1655	4689	2006/01/22 06:23	21 15.1470	139 32.1782	4693	21 15.1434	139 32.0352	4715.5
5	2006/01/13 00:27	21_17.1845	139_34.0067	4567	2006/01/22 04:54	21_17.2449	139_33.9791	4633	21_17.2072	139_33.9076	4632.2
6	2006/01/12 23:11	21_19.2632	139_35.8620	4367	2006/01/22 03:19	21_19.3043	139_35.8034	4394	21_19.2770	139_35.7359	4445.6
7	2006/01/12 22:02	21 21.3296	139 37.7092	3931	2006/01/22 01:45	21 21.3230	139 37.6649	3944	21 21.3270	139 37.6182	3962.5
8	2006/01/12 20:53	21 23.3931	139 39.6068	3831	2006/01/22 00:16	21 23.3770	139 39.5320	3882	21 23.3886	139 39.4980	3901.0
9	2006/01/12 07:59	21_25.4713	139_41.4868	3873	2006/01/21 22:51	21_25.4261	139_41.3943	3863	21_25.4628	139_41.3729	3895.7
10	2006/01/12 06:49	21_27.5392	139_43.3310	3920	2006/01/23 23:26	21_27.5057	139_43.2454	3987	21_27.5292	139_43.1791	4014.5
11	2006/01/12 05:37	21 29.6135	139 45.1783	3988	2006/01/21 19:58	21 29.5771	139 45.1648	4030	21 29.5897	139 45.0894	3988.2
12	2006/01/12 04:26	21 31.6729	139 47.0869	3887	–	–	–	–	21 31.6402	139 46.9355	3909.0
13	2006/01/12 03:14	21_33.7488	139_48.9118	3721	2006/01/21 15:50	21_33.6513	139_48.9170	3769	21_33.7195	139_48.8209	3729.8
14	2006/01/12 02:05	21_35.8253	139_50.7977	3832	2006/01/20 17:00	21_56.3548	140_06.4935	4318	21_35.8072	139_50.7176	3750.6
15	2006/01/12 00:57	21 37.8749	139 52.6448	4071	2006/01/21 13:57	21 37.8628	139 52.6303	4053	21 37.8556	139 52.6036	4097.2
16	2006/01/11 23:38	21 39.9385	139 54.5042	4236	2006/01/21 12:29	21 39.9025	139 54.5146	4238	21 39.8884	139 54.5148	4297.6
17	2006/01/11 22:22	21_41.9987	139_56.3476	4375	2006/01/21 10:59	21_42.0033	139_56.2819	4378	21_41.9871	139_56.2982	4360.9
18	2006/01/11 21:02	21_44.0748	139_58.2222	4361	2006/01/21 09:26	21_44.0413	139_58.1909	4323	21_44.0463	139_58.1544	4337.7
19	2006/01/11 00:49	21 46.1721	140 00.0628	4175	2006/01/21 07:52	21 46.0507	140 00.0824	4232	21 46.1009	140 00.1020	4194.2
20	2006/01/10 23:14	21 48.2184	140 01.9713	4316	2006/01/21 06:22	21 48.2827	140 01.9098	4337	21 48.1507	140 01.9252	4391.9
21	2006/01/10 21:41	21_50.3130	140_03.8622	4327	2006/01/21 04:50	21_50.4096	140_03.9663	4293	21_50.2740	140_03.9442	4238.4
22	2006/01/10 20:02	21_52.3081	140_05.6546	4418	2006/01/21 03:14	21_52.2806	140_05.7562	4412	21_52.3263	140_05.7681	4392.5
23	2006/01/10 18:26	21 54.3830	140 07.5193	4480	2006/01/21 01:46	21 54.2717	140 07.6076	4480	21 54.3101	140 07.6067	4518.1
24	2006/01/10 16:56	21 56.4331	140 09.3998	4523	2006/01/21 00:00	21 56.3256	140 09.4492	4523	21 56.3987	140 09.4045	4539.1
25	2006/01/10 15:32	21_58.4919	140_11.2792	4379	2006/01/20 22:27	21_58.4381	140_11.3462	4399	21_58.5486	140_11.3435	4330.6
26	2006/01/10 14:13	22_00.5582	140_13.1434	4154	2006/01/20 20:53	22_00.4870	140_13.3025	4169	22_00.5477	140_13.2918	4098.7
27	2006/01/10 12:56	22 02.6183	140 15.0041	4000	2006/01/20 19:20	22 02.5376	140 15.2827	4062	22 02.6384	140 15.1689	3999.9
28	2006/01/10 11:34	22 04.6833	140 16.8959	4513	2006/01/20 13:02	22 04.6217	140 17.2730	4550	22 04.7288	140 17.0841	4487.8
29	2006/01/10 10:16	22_06.7463	140_18.7735	4511	2006/01/20 11:17	22_06.8219	140_19.0766	4527	22_06.8264	140_18.8154	4535.1
30	2006/01/10 08:54	22_08.8156	140_20.6406	4395	2006/01/20 09:43	22_08.8414	140_20.8373	4411	22_08.8738	140_20.7208	4323.2
31	2006/01/10 07:36	22 10.8784	140 22.5112	4273	2006/01/20 08:09	22 10.9221	140 22.7293	4292	22 10.8926	140 22.5399	4325.0
32	2006/01/10 06:20	22 12.9247	140 24.3937	3930	2006/01/20 06:41	22 12.9499	140 24.6148	3924	22 12.9837	140 24.5182	3883.6
33	2006/01/10 05:08	22_14.9805	140_26.2722	3673	2006/01/20 05:18	22_15.0065	140_26.4350	3681	22_15.0648	140_26.2855	3641.3
34	2006/01/10 04:03	22_17.0441	140_28.1492	2949	2006/01/20 03:52	22_17.0920	140_28.3506	2995	22_17.0652	140_28.1189	2963.2
35	2006/01/10 02:55	22 19.1281	140 30.0485	2924	2006/01/20 02:26	22 19.2473	140 30.2838	2919	22 19.1714	140 30.0360	2939.9
36	2006/01/10 01:50	22 21.1854	140 31.9441	3124	2006/01/20 01:16	22 21.3567	140 32.1591	3092	22 21.2168	140 31.9295	2871.4
37	2006/01/10 00:42	22_23.2533	140_33.8315	3091	2006/01/19 23:45	22_23.4616	140_33.0288	3007	22_23.2573	140_33.8204	2914.8
38	2006/01/09 23:31	22_25.3065	140_35.7033	2992	2006/01/19 22:16	22_25.5222	140_35.9102	2898	22_25.3397	140_35.7310	2953.3
39	2006/01/09 22:18	22 27.3714	140 37.5926	2861	2006/01/19 20:51	22 27.6197	140 37.8598	2826	22 27.4185	140 37.6098	2839.5
40	2006/01/09 20:52	22 29.4265	140 39.4778	2760	2006/01/19 19:30	22 29.6325	140 39.7520	2728	22 29.4916	140 39.5934	2723.3
41	2006/01/09 19:30	22_31.4851	140_41.3660	3033	2006/01/19 18:24	22_31.6533	140_41.7289	3062	22_31.5307	140_41.4986	3027.6
42	2006/01/09 18:00	22_33.5432	140_43.2481	3455	2006/01/19 17:10	22_33.6747	140_43.6156	3445	22_33.5727	140_43.3277	3445.0
43	2006/01/09 16:35	22 35.5923	140 45.1572	3600	2006/01/19 15:49	22 35.6901	140 45.5593	3642	22 35.6078	140 45.2289	3624.4
44	2006/01/09 15:05	22 37.6540	140 47.0384	3739	2006/01/19 13:50	22 37.6550	140 47.4038	3758	22 37.7401	140 47.1487	3728.2
45	2006/01/09 13:29	22_39.7301	140_48.9173	3819	2006/01/19 12:27	22_39.6419	140_49.3373	3797	22_39.7842	140_49.1078	3733.2
46	2006/01/09 12:01	22_41.7693	140_50.8205	3716	2006/01/19 10:59	22_41.7029	140_51.1577	3710	22_41.8095	140_50.8835	3709.2
47	2006/01/09 09:57	22 43.8205	140 52.7252	3545	2006/01/19 09:33	22 43.7565	140 53.0678	3515	22 43.8952	140 52.8855	3527.7
48	2006/01/09 08:30	22 45.8929	140 54.5682	3494	2006/01/19 08:10	22 45.9255	140 54.7693	3509	22 45.9641	140 54.6490	3506.6
49	2006/01/09 07:03	22_47.9425	140_56.5066	3464	2006/01/19 06:51	22_48.0023	140_56.7398	3470	22_47.9960	140_56.6167	3457.2
50	2006/01/09 05:35	22_50.0000	140_58.3922	3441	2006/01/19 05:38	22_50.1211	140_58.5026	3445	22_50.0111	140_58.4428	3449.8
51	2006/01/09 04:15	22 52.0540	141 00.3020	3559	2006/01/19 04:28	22 52.1686	141 00.2863	3539	22 52.0628	141 00.3294	3546.8
52	2006/01/09 02:55	22 54.1026	141 02.1898	3467	2006/01/19 03:19	22 54.1296	141 02.1879	3482	22 54.0749	141 02.2580	3484.5
53	2006/01/09 01:39	22_56.1516	141_04.0822	3386	2006/01/19 02:02	22_56.1921	141_04.0781	3378	22_56.1270	141_04.0693	3405.6
54	2006/01/09 00:24	22_58.2137	141_06.9863	3249	2006/01/19 00:46	22_58.1935	141_06.0255	3251	22_58.1525	141_06.0793	3244.1
55	2006/01/08 23:11	23 00.2714	141 07.9013	3053	2006/01/18 23:36	23 00.2530	141 07.8675	3073	23 00.2623	141 07.8878	3089.4
56	2006/01/08 22:01	23 02.3184	141 09.7944	2648	2006/01/18 22:26	23 02.2665	141 09.8585	2632	23 02.3219	141 09.8214	2639.2
57	2006/01/08 20:55	23_04.3721	141_11.6534	2432	2006/01/18 21:21	23_04.3186	141_11.7884	2439	23_04.3907	141_11.7606	2414.7
58	2006/01/08 19:52	23_06.4272	141_13.5657	2247	2006/01/18 20:19	23_06.3579	141_13.7454	2209	23_06.4398	141_13.6563	2222.8
59	2006/01/08 18:47	23 08.4905	141 15.4825	2230	2006/01/18 19:19	23 08.4068	141 15.6960	2171	23 08.5178	141 15.5542	2346.0
60	2006/01/08 17:45	23 10.5433	141 17.3923	1831	2006/01/18 18:16	23 10.4596	141 17.6452	1774	23 10.5604	141 17.4553	1817.1
61	2006/01/08 16:52	23_12.5778	141_19.2813	1391	2006/01/18 17:16	23_12.4244	141_19.7309	1115	23_12.9767	141_19.7361	1369.9
62	2006/01/08 15:54	23_14.6267	141_21.1909	1782	2006/01/18 16:12	23_14.5493	141_21.6937	1734	23_14.6404	141_21.2511	1751.6
63	2006/01/08 14:26	23 16.6853	141 23.0970	1569	2006/01/18 15:10	23 16.5365	141 23.4758	1504	23 16.6291	141 23.1529	1592.4
64	2006/01/08 13:37	23 18.7231	141 25.0021	1311	2006/01/18 13:54	23 18.7204	141 25.1233	1286	23 18.7158	141 25.0450	1299.9
65	2006/01/08 12:51	23_20.7924	141_26.9209	1058	2006/01/18 12:45	23_20.8356	141_26.7890	1031	23_20.7643	141_26.9134	1061.7
66	2006/01/08 12:06	23_22.8390	141_28.8360	632	2006/01/18 11:43	23_22.8379	141_28.7705	614	23_22.7669	141_28.8568	623.9
67	2006/01/08 11:23	23 24.8835	141 30.7430	681	2006/01/18 10:42	23 24.9275	141 30.6868	685	23 24.8537	141 30.7812	696.6
68	2006/01/08 10:38	23 26.9212	141 32.6477	1004	2006/01/18 09:39	23 27.0489	141 32.5196	1060	23 26.9075	141 32.6667	963.7
69	2006/01/08 09:50	23_28.2909	141_34.5803	1197	2006/01/18 08:43	23_28.9499	141_34.6109	1199	23_28.9663	141_34.6895	1190.0
70	2006/01/08 08:59	23_31.0173	141_36.5055	1274	2006/01/18 07:48	23_30.9941	141_36.4962	1272	23_31.0031	141_36.6051	1276.4
71	2006/01/08 08:06	23 33.0828	141 38.4326	1385	2006/01/18 06:41	23 33.0766	141 38.4761	1391	23 33.1066	141 38.5289	1371.2
72	2006/01/08 07:14	23 35.1219	141 40.3344	1387	2006/01/18 05:44	23 35.1159	141 40.3950	1407	23 35.1199	141 40.4218	1401.3
73	2006/01/08 06:23	23_37.1559	141_42.2506	1315	2006/01/18 04:48	23_37.2815	141_42.2886	1310	23_37.2346	141_42.3229	1292.3
74	2006/01/08 05:34	23_39.2174	141_44.1818	1332	2006/01/18 03:58	23_39.2966	141_44.2621	1339	23_39.2460	141_44.2637	1310.3
75	2006/01/08 04:45	23 41.2485	141 46.1123	1298	2006/01/18 03:01	23 41.2117	141 46.1726	1313	23 41.2320	141 46.2656	1353.2
76	2006/01/08 03:54	23 43.2992	141 48.0308	1297	2006/01/18 02:09	23 43.3011	141 48.0889	1290	23 43.3369	141 48.1107	1294.5
77	2006/01/08 03:00	23_45.3472	141_49.9415	1863	2006/01/18 01:19	23_45.2699	141_50.0433	1827	23_45.3222	141_50.0193	1828.3
78	2006/01/08 02:00	23_47.4090	141_51.8821	2252	2006/01/18 00:29	23_47.2323	141_51.9854	2224	23_47.3450	141_51.9782	2197.9
79	2006/01/08 00:51	23 49.4324	141 53.8066	2472	2006/01/17 23:31	23 49.2239	141 53.9137	2470	23 49.3609	141 53.9018	2454.1
80	2006/01/07 23:36	23 51.4945	141 55.7265	2608	2006/01/17 22:25	23 51.2711	141 55.8739	2640	23 51.4165	141 55.8628	2610.7
81	2006/01/07 22:23	23_53.5226	141_57.6689	2781	2006/01/17 21:20	23_53.3296	141_57.6308	2774	23_53.4956	141_57.5609	2775.9
82	2006/01/07 21:13	23_55.5639	141_59.5811	2830	2006/01/17 20:07	23_55.4326	141_59.8151	2831	23_55.5004	141_59.7279	2796.6
83	2006/01/07 17:15	23 57.6059	142 01.5007	2840	2006/01/17 18:52	23 57.6181	142 01.8470	2840	23 57.5960	142 01.5765	2838.3
84	2006/01/07 16:05	23 59.6539	142 03.4326	2776	2006/01/17 17:32	23 59.7193	142 03.6688	2770	23 59.6587	142 03.4803	2767.7
85	2006/01/07 14:52	24_01.6998	142_05.3741	2742	2006/01/17 16:17	24_01.8106	142_05.6136	2731	24_01.7221	142_05.4311	2724.6
86	2006/01/07 13:44	24_03.7424	142_07.3016	2695	2006/01/17 15:06	24_03.7974	142_07.4244	2694	24_03.7861	142_07.3357	2679.5
87	2006/01/07 12:34	24 05.7779	142 09.2374	2647	2006/01/17 13:59	24 05.7340	142 09.3784	2645	24 05.7630	142 09.3535	2627.1
88	2006/01/07 11:29	24 07.8232	142 11.1746	2537	2006/01/17 12:53	24 07.8639	142 11.2008	2536	24 07.8804	142 11.1646	2524.7
89	2006/01/07 10:25	24_09.8750	142_13.1143	2549	2006/01/17 11:45	24_09.9508	142_13.1063	2544	24_09.9400	142_13.1384	2531.7
90	2006/01/07 09:17	24_11.9200	142_15.0429	2543	2006/01/17 10:36	24_12.0238	142_15.0144	2538	24_12.0013	142_15.0731	2538.0
91	2006/01/07 08:08	24 13.9371	142 16.9692	2578	2006/01/17 09:28	24 14.0772	142 16.8819	2572	24 13.9907	142 17.0443	2574.1
92	2006/01/07 07:02	24 15.9784	142 18.9019	2819	2006/01/17 08:22	24 16.1178	142 18.8495	2599	24 16.0717	142 18.9729	2577.4
93	2006/01/07 05:55	24_18.0272	142_20.8658	2667	2006/01/17 07:13	24_18.1039	142_20.7304	2638	24_18.1372	142_20.9023	2671.7
94	2006/01/07 04:49	24_20.0660	142_22.7939	2694	2006/01/17 06:06	24_20.1171	142_22.6786	2677	24_20.1763	142_22.8129	2659.2
95	2006/01/07 03:41	24 22.1010	142 24.7363	2673	2006/01/17 05:01	24 22.1533	142 24.6336	2670	24 22.2312	142 24.7185	2649.4
96	2006/01/07 02:31	24 24.1300	142 26.6809	2644	2006/01/17 03:58	24 24.1452	142 26.6214	2648	24 24.4418	142 27.0877	2647.2
97	2006/01/07 01:19	24_26.1750	142_28.6282	2772	2006/01/17 02:58	24_26.1767	142_28.5831	2780	24_26.2554	142_28.6119	2742.2
98	2006/01/07 00:02	24_28.1953	142_30.5721	2932	2006/01/17 01:48	24_28.1821	142_30.5790	2930	24_28.2960	142_30.5491	2913.8
99	2006/01/06 22:44	24 30.2312	142 32.5263	2956	2006/01/17 00:40	24 30.1625	142 32.5676	2955	24 30.3418	142 32.5263	2940.5
100	2006/01/06 21:25	24_32.2564	142_34.4423	2967	2006/01/16 23:31	24_32.2009	142_34.5214	2965	24_32.3415	142_34.4347	2973.4

Table 6: OBS positions of KR0605

SITE	Deployment				Retrieval				OBS Position		
	Time	Position			Time	Position					
	UTC	Lat(N)	Lon(E)	Depth	UTC	Lat(N)	Lon(E)	Depth	Lat(N)	Lon(E)	Depth
1	2006/05/15 21:05:00	32_01.8620	138_33.4266	2587	2006/05/25 04:09:00	32_01.4588	138_33.3451	2673	32_01.6393	138_33.3207	2643.5
2	2006/05/15 23:29:00	31_59.1835	138_33.6714	2820	2006/05/25 05:35:00	31_58.9800	138_33.7556	2823	31_59.1571	138_33.7112	2817.8
3	2006/05/16 00:51:00	31 56.4857	138 33.9951	2951	2006/05/25 06:35:00	31 56.3537	138 34.0040	2971	31 56.5244	138 34.0162	2966.3
4	2006/05/16 02:40:00	31 53.8215	138 34.2688	2877	2006/05/25 07:37:00	31 53.7067	138 34.3539	2865	31 53.8797	138 34.3831	2888.4
5	2006/05/16 03:15:00	31_51.1310	138_34.5570	2709	2006/05/25 08:37:36	31_51.0349	138_34.7268	2697	31_51.1723	138_34.7079	2712.0
6	2006/05/16 04:24:00	31 48.4346	138 34.8489	2171	2006/05/25 09:34:48	31 48.4551	138 35.0718	2103	31 48.5125	138 35.0627	2252.2
7	2006/05/16 05:27:00	31 45.7500	138 35.1334	953	2006/05/25 10:22:25	31 45.6139	138 35.2901	977	31 45.6903	138 35.2373	938.3
8	2006/05/16 06:15:00	31_43.0697	138_35.4196	1991	2006/05/25 12:09:00	31_42.9383	138_35.5749	2082	31_43.0694	138_35.5156	1989.9
9	2006/05/16 07:25:00	31_40.3755	138_35.7011	3221	2006/05/25 13:53:00	31_40.2630	138_35.6636	3227	31_40.3782	138_35.7265	3209.6
10	2006/05/16 08:53:00	31 37.6953	138 35.9911	3365	2006/05/25 15:44:00	31 37.4902	138 35.8355	3385	31 37.7118	138 35.9435	3359.4
11	2006/05/16 10:15:00	31_35.0089	138_36.2778	3406	2006/05/25 17:31:00	31_34.9713	138_36.1042	3419	31_35.0433	138_36.2033	3406.1
12	2006/05/16 11:42:00	31_32.3065	138_36.5660	3364	2006/05/25 19:19:00	31_32.2808	138_36.5364	3362	31_32.3467	138_36.5589	3357.0
13	2006/05/16 13:07:00	31 29.6153	138 36.8534	3350	2006/05/25 21:11:00	31 29.6175	138 36.9255	3346	31 29.6533	138 36.9104	3344.7
14	2006/05/16 14:28:00	31 26.9262	138 37.1368	3270	2006/05/25 23:01:00	31 26.8828	138 37.3120	3260	31 26.9360	138 37.1782	3263.7
15	2006/05/16 15:48:00	31_24.2366	138_37.4161	2838	2006/06/26 00:42:00	31_24.1266	138_37.6064	2843	31_24.2144	138_37.4407	2897.2
16	2006/05/16 17:03:00	31 21.5546	138 37.7043	1592	2006/05/26 02:00:00	31 21.4205	138 37.7930	1551	31 21.5329	138 37.6967	1587.6
17	2006/05/16 18:03:00	31 18.8884	138 37.9888	2390	2006/05/26 03:23:00	31 18.7470	138 38.0683	2410	31 18.8361	138 37.9877	2401.9
18	2006/05/16 19:12:35	31_16.1918	138_38.2626	2755	2006/05/26 04:44:00	31_16.1269	138_38.2313	2791	31_16.1924	138_38.2204	2766.9
19	2006/05/16 20:22:00	31_13.4925	138_38.5549	2896	2006/05/26 06:10:00	31_13.4673	138_38.4087	2905	31_13.5325	138_38.5135	2890.3
20	2006/05/16 21:39:00	31 10.7982	138 38.8515	3205	2006/05/26 07:45:00	31 10.7245	138 38.7525	3212	31 10.8044	138 38.8389	3203.9
21	2006/05/16 22:54:00	31_08.1183	138_39.1277	3293	2006/05/26 09:15:00	31_08.1609	138_39.1419	3291	31_08.1737	138_39.1364	3280.6
22	2006/05/17 00:10:00	31_05.4538	138_39.4062	3349	2006/05/31 06:23:00	31_05.4121	138_39.8372	3347	31_05.5017	138_39.4789	3344.5
23	2006/05/17 01:27:00	31 02.7694	138 39.6889	3338	2006/05/26 11:58:00	31 02.9354	138 39.7088	3344	31 02.8645	138 39.7946	3336.1
24	2006/05/17 02:45:00	31 00.0775	138 39.9759	3101	2006/05/31 03:59:00	31 00.1660	138 40.3084	3070	31 00.1254	138 40.1075	3068.2
25	2006/05/17 04:03:00	30_57.3935	138_40.2590	2381	2006/05/31 02:19:00	30_57.4097	138_40.4831	2344	30_57.4211	138_40.3460	2392.6
26	2006/05/17 05:12:00	30 54.7044	138 40.5379	954	2006/05/31 00:58:00	30 54.7479	138 40.6968	986	30 54.7308	138 40.5818	967.7
27	2006/05/17 06:02:00	30 52.0180	138 40.8165	574	2006/05/30 23:40:00	30 52.0121	138 40.8632	696	30 52.0188	138 40.8443	553.7
28	2006/05/17 06:49:00	30_49.3298	138_41.1034	1604	2006/05/30 22:30:00	30_49.3896	138_41.0923	1586	30_49.3403	138_41.1494	1596.2
29	2006/05/17 07:49:00	30_46.6481	138_41.3826	2274	2006/05/30 21:16:00	30_46.6492	138_41.4014	2279	30_46.6554	138_41.4810	2271.6
30	2006/05/17 08:55:00	30 43.9502	138 41.6670	2597	2006/05/30 19:58:00	30 43.9463	138 41.6009	2608	30 43.9564	138 41.6733	2591.7
31	2006/05/17 10:27:00	30_41.2722	138_41.9480	2074	2006/05/30 18:32:00	30_41.2203	138_41.9634	2021	30_41.2660	138_41.9617	2089.8
32	2006/05/17 11:30:00	30_38.5630	138_42.2286	2023	2006/05/30 17:16:00	30_38.5263	138_42.2910	2043	30_38.5746	138_42.2587	2027.5
33	2006/05/17 12:35:00	30 35.8789	138 42.5001	2073	2006/05/30 15:53:00	30 35.8540	138 42.6058	2012	30 35.8907	138 42.5529	2040.4
34	2006/05/17 13:40:00	30 33.1863	138 42.7906	1736	2006/05/30 14:29:00	30 33.1754	138 42.9365	1733	30 33.2068	138 42.8418	1732.9
35	2006/05/17 15:14:00	30_30.5081	138_43.0607	2078	2006/05/30 13:07:00	30_30.5188	138_43.2857	2081	30_30.5174	138_43.1556	2079.7
36	2006/05/17 16:20:00	30 27.8234	138 43.3395	2237	2006/05/30 11:41:00	30 27.8712	138 43.5484	2260	30 27.8292	138 43.4526	2249.9
37	2006/05/17 18:09:00	30 25.1354	138 43.6416	2795	2006/05/30 10:20:00	30 25.1794	138 43.7871	2786	30 25.1517	138 43.7071	2781.8
38	2006/05/17 19:22:00	30_22.4346	138_43.9123	2930	2006/05/30 08:49:00	30_22.5243	138_44.0681	2934	30_22.4569	138_43.9612	2928.9
39	2006/05/17 20:41:00	30_19.7507	138_44.1840	2850	2006/05/30 07:21:00	30_19.8761	138_44.4270	2833	30_19.7751	138_44.2514	2844.3
40	2006/05/17 21:57:00	30 17.0642	138 44.4649	3051	2006/05/30 05:51:00	30 17.1696	138 44.7809	3042	30 17.1042	138 44.5100	3048.2
41	2006/05/17 23:31:00	30_14.3948	138_44.7487	2888	2006/05/30 04:19:00	30_14.4371	138_45.2751	2889	30_14.4246	138_44.8420	2889.0
42	2006/05/18 00:46:00	30_11.7011	138_45.0336	1655	2006/05/30 02:37:00	30_11.7609	138_45.4739	1716	30_11.7341	138_45.1326	1705.5
43	2006/05/18 01:47:00	30 09.0193	138 45.3010	1630	2006/05/29 23:11:00	30 09.0455	138 45.7038	1663	30 09.0511	138 45.4167	1660.7
44	2006/05/18 04:22:00	30 06.3333	138 45.5887	1954	2006/05/29 22:14:00	30 06.4320	138 45.9743	1951	30 06.3921	138 45.7889	1947.7
45	2006/05/18 05:26:00	30_03.6380	138_45.8493	2126	2006/05/29 21:24:00	30_03.6716	138_46.2764	2092	30_03.6225	138_46.0761	2142.2
46	2006/05/18 06:27:00	30 00.9588	138 46.1346	2404	2006/05/29 20:29:00	30 01.0252	138 46.4538	2387	30 00.9883	138 46.2985	2391.3
47	2006/05/18 07:33:00	29 58.2657	138 46.4139	2625	2006/05/29 19:30:00	29 58.3526	138 46.8011	2570	29 58.2697	138 46.6660	2594.3
48	2006/05/18 08:42:00	29_55.5832	138_46.6867	2600	2006/05/29 18:27:00	29_55.6652	138_46.9910	2576	29_55.5943	138_46.8320	2584.8
49	2006/05/18 09:50:00	29_52.8984	138_46.9567	2562	2006/05/29 17:27:00	29_52.8404	138_47.3237	2555	29_52.8388	138_47.1344	2557.0
50	2006/05/18 10:59:00	29 50.1851	138 47.2371	1683	2006/05/29 16:23:00	29 50.1486	138 47.4076	1601	29 50.2044	138 47.2788	1754.4
51	2006/05/18 11:52:00	29_47.4922	138_47.5241	1484	2006/05/29 15:23:00	29_47.4540	138_47.7674	1475	29_47.5041	138_47.5882	1486.6
52	2006/05/18 12:42:00	29_44.8087	138_47.8072	1273	2006/05/29 14:26:00	29_44.7495	138_47.9856	1310	29_44.8038	138_47.8390	1281.1
53	2006/05/18 13:29:00	29 42.1305	138 48.0790	2003	2006/05/29 13:25:00	29 42.0034	138 48.1809	2074	29 42.0624	138 48.0536	2072.2
54	2006/05/18 14:26:00	29 39.4366	138 48.3388	2724	2006/05/29 12:22:00	29 39.2795	138 48.5106	3003	29 39.4259	138 48.3747	2724.8
55	2006/05/18 15:36:00	29_36.7475	138_48.6183	2872	2006/05/29 11:18:00	29_36.6202	138_48.8313	2886	29_36.7364	138_48.6781	2858.2
56	2006/05/18 16:47:00	29 34.0606	138 48.8881	2814	2006/05/29 10:11:00	29 34.0128	138 49.0870	2790	29 34.0263	138 48.9465	2806.4
57	2006/05/18 17:59:00	29 31.3729	138 49.1610	2426	2006/05/29 09:05:00	29 31.3269	138 49.3426	2381	29 31.3335	138 49.1900	2424.8
58	2006/05/18 19:09:00	29_28.6862	138_49.4343	2630	2006/05/29 07:57:00	29_28.6057	138_49.5896	2612	29_28.6201	138_49.4642	2687.0
59	2006/05/18 20:16:00	29_26.0287	138_49.7089	2680	2006/05/29 06:53:00	29_25.9926	138_49.7762	2676	29_25.9976	138_49.6490	2675.5
60	2006/05/18 20:23:00	29 23.3388	138 49.9842	2500	2006/05/29 05:47:00	29 23.3295	138 50.0166	2498	29 23.3070	138 49.8622	2504.2
61	2006/05/18 22:29:00	29_20.6563	138_50.2575	2532	2006/05/29 04:45:00	29_20.6046	138_50.2098	2536	29_20.6077	138_50.0925	2549.2
62	2006/05/18 23:39:00	29_17.9601	138_50.5542	2488	2006/05/29 03:45:00	29_18.0798	138_50.4070	2486	29_18.0762	138_50.2916	2489.3
63	2006/05/19 00:52:00	29 15.2731	138 50.7986	2466	2006/05/29 02:49:00	29 15.3030	138 50.7658	2469	29 15.2469	138 50.6326	2482.7
64	2006/05/19 01:59:00	29 12.5842	138 51.0804	2376	2006/05/29 01:51:00	29 12.6173	138 50.9483	2363	29 12.5616	138 50.8931	2361.7
65	2006/05/19 03:04:00	29_09.8983	138_51.3530	2277	2006/05/29 00:54:00	29_10.0440	138_51.1524	2279	29_09.8947	138_51.2027	2289.6
66	2006/05/19 04:08:00	29 07.2073	138 51.6289	2194	2006/05/28 23:48:00	29 07.3634	138 51.4121	2259	29 07.2474	138 51.5576	2207.3
67	2006/05/19 05:14:00	29 04.5198	138 51.9011	2072	2006/05/28 22:40:00	29 04.5495	138 51.5991	2068	29 04.5631	138 51.8630	2086.3
68	2006/05/19 06:21:00	29_01.8359	138_52.1747	2181	2006/05/28 21:37:00	29_01.7821	138_51.8867	2212	29_01.8854	138_52.2148	2172.2
69	2006/05/19 07:27:00	28_59.1487	138_52.4422	1864	2006/05/28 20:34:00	28_59.1028	138_52.1809	1902	28_59.1980	138_52.5196	1851.9
70	2006/05/19 08:29:00	28 56.4593	138 52.7089	2107	2006/05/28 19:26:00	28 56.3516	138 52.4214	2144	28 56.5018	138 52.8094	2106.0
71	2006/05/19 09:35:00	28_53.7721	138_52.9818	2510	2006/05/28 18:14:00	28_53.6448	138_52.7323	2546	28_53.8100	138_53.0497	2497.5
72	2006/05/19 10:44:00	28_51.0817	138_53.2520	2897	2006/05/28 16:57:00	28_50.9041	138_52.9685	2913	28_51.1267	138_53.2910	2879.7
73	2006/05/19 11:58:00	28 48.3742	138 53.5278	3136	2006/05/28 15:34:00	28 48.2177	138 53.3367	3124	28 48.3861	138 53.5517	3142.0
74	2006/05/19 13:13:00	28 45.6858	138 53.7954	3051	2006/05/28 14:12:00	28 45.5215	138 53.6617	3091	28 45.6867	138 53.8356	3044.0
75	2006/05/19 14:28:00	28_42.9986	138_54.0662	2710	2006/05/28 13:01:00	28_42.8556	138_53.8978	2712	28_42.9915	138_54.0567	2722.7
76	2006/05/19 15:39:00	28 40.3124	138 54.3410	2790	2006/05/28 11:47:00	28 40.1147	138 54.2000	2648	28 40.3160	138 54.3683	2799.8
77	2006/05/19 16:53:00	28 37.6246	138 54.6097	2796	2006/05/28 10:35:00	28 37.4714	138 54.5020	2771	28 37.6251	138 54.6613	2798.9
78	2006/05/19 18:03:00	28_34.9368	138_54.8757	3085	2006/05/28 09:30:00	28_34.7786	138_54.7111	3073	28_34.9354	138_54.9001	3099.2
79	2006/05/19 19:21:00	28_32.2513	138_55.1471	2904	2006/05/28 08:21:00	28_31.9766	138_55.1517	2902	28_32.0984	138_55.3238	2951.5
80	2006/05/19 20:34:00	28 29.5800	138 55.4029	2915	2006/05/28 07:14:00	28 29.4147	138 55.2558	2837	28 29.5516	138 55.3868	2904.0
81	2006/05/19 21:51:00	28_26.8942	138_55.6839	2840	2006/05/28 06:08:00	28_26.7445	138_55.5708	2831	28_26.8748	138_55.6617	2845.5
82	2006/05/19 23:05:00	28_24.2138	138_55.9520	2819	2006/05/28 05:07:00	28_24.1169	138_55.8511	2778	28_24.2305	138_55.9045	2810.7
83	2006/05/20 00:18:00	28 21.5226	138 56.2182	2858	2006/05/28 04:01:00	28 21.3691	138 56.4006	2911	28 21.4823	138 56.4226	2851.0
84	2006/05/20 01:33:00	28 18.8330	138 56.4843	2977	2006/05/28 02:58:00	28 18.7828	138 56.4297	2975	28 18.8532	138 56.4642	2979.5
85	2006/05/20 02:49:00	28_16.1482	138_56.7499	2956	2006/05/28 01:51:00	28_16.1249	138_56.6973	2995	28_16.1914	138_56.7590	2940.5
86	2006/05/20 04:04:00	28 13.4629	138 57.0180	2789	2006/05/28 00:48:00	28 13.3959	138 56.9975	2786	28 13.5168	138 57.0451	2795.7
87	2006/05/20 05:17:00	28 10.7732	138 57.2875	2955	2006/05/27 23:41:00	28 10.7239	138 57.1767	2951	28 10.8454	138 57.3064	2967.1
88	2006/05/20 06:32:00	28_08.0857	138_57.5604	2915	2006/05/27 22:28:00	28_08.0231	138_57.4311	2935	28_08.1578	138_57.6053	2910.3
89	2006/05/20 07:48:00	28_05.3995	138_57.8240	2956	2006/05/27 21:15:00	28_05.2849	138_57.5879	2983	28_05.4549	138_57.8331	2976.5
90	2006/05/20 09:02:00	28 02.7097	138 58.0898	2985	2006/05/27 18:38:00	28 02.6356	138 57.7932	2992	28 02.7661	138 58.0547	2988.6
91	2006/05/20 10:20:00	28_00.0162	138_58.3521	2898	2006/05/27 17:14:00	27_59.8630	138_58.0360	2896	28_00.0569	138_58.2822	2884.2
92	2006/05/20 11:35:00	27_57.3279	138_58.6231	2627	2006/05/27 15:48:00	27_57.1441	138_58.3766	2518	27_57.3324	138_58.5510	2660.9
93	2006/05/20 12:46:00	27 54.6303	138 58.8788	2859	2006/05/27 14:20:00	27 54.4363	138 58.6445	2948	27 54.6652	138 58.7598	2866.2
94	2006/05/20 14:00:00	27 51.9497	138 59.1459	2861	2006/05/27 12:54:00	27 51.7695	138 58.9575	2829	27 51.9873	138 59.0258	2867.3
95	2006/05/20 15:11:00	27_49.2504	138_59.4051	2794	2006/05/27 11:26:00	27_49.0795	138_59.1471	2837	27_49.3114	138_59.2951	2807.5
96	2005/05/20 16:22:00	27 46.5718	138 59.6882	3286	2006/05/27 09:58:00	27 46.3459	138 59.4107	3301	27 46.6042	138 59.5704	3288.6
97	2006/05/20 17:43:00	27 43.8851	138 59.9435	3815	2006/05/27 08:50:00	27 43.6563	138 59.6794	3846	27 43.9035	138 59.8904	3838.4
98	2006/05/20 19:14:00	27_41.1962	139_00.2050	3838	2006/05/27 07:32:00	27_41.0265	138_59.9753	3830	27_41.2125	139_00.1602	3838.1
99	2006/05/20 20:42:00	27_38.5153	139_00.4660	3827	2006/05/27 06:13:00	27_38.3695	139_00.3114	3879	27_38.5226	139_00.4274	3861.0
100	2006/05/20 22:12:00	27 35.8305	139 00.7416	3797	2006/05/27 04:54:00	27 35.7148	139 00.6226	3790	27 35.8240	139 00.6604	3802.2

for one OBS which was used in KR0601 (Site 22). The OBSs used (4.5 Hz, three-component gimbal-mounted geophones and hydrophones, continuous 16-bit digital recording with 100 Hz) were originally designed by Kanazawa and Shiobara (1994) and Shinohara et al. (1993). Continuous round motions were recorded on digital audiotape or a hard disk. Rechargeable lithium-ion batteries are used as an electric power supply. All parts including sensors with gimbal-leveling mechanism, batteries and a recorder are installed in 17-inch glass spheres made by Benthos, Inc, USA and Nautilus Marine service Gmbh, Germany. An OBS equipped an acoustic transponder system which control release mechanism as well as positioning system. An OBS is released from anchors by electric corrosion of stainless plates when a release command was send from the vessel. For positioning an OBS, super short base line (SSBL) acoustic positioning system is used. An accuracy of the SSBL system is about 3 % of water depth. After correcting a drift of an OBS clock by comparing the OBS clock and GPS, 70 s long data for each shots are formatted with SEG-Y.

3.3 Streamer cable

For acquiring the multichannel reflection seismic data during KR0605, we used a 204-channle hydrophone streamer cable made by Sercel Inc. (Fig. 4) The streamer cable is composed of 68 active sections, and each active section is 75m long and consists of three receiver groups (channels). The active modules including 24bit A/D converters are inserted every four active sections and collect seismic data from the four sections. The interval of each group is 25m. The lengths of total active section and lead-in cable are 5100m (75m × 68) and 110m, respectively. Hydrophone sensors (Benthos Reduce Diameter Array hydrophone) with sensitivity of 20V/Bar are used and the signals from 32 sensors in the same group (channel) are stacked before A/D conversion. The towing depth of streamer cable was controlled to be 15m below sea surface by the depth controller called Bird (DigiCOURSE System3).

3.4 Recoding and navigation system

The recording system of multichannel reflection data is the SYNTRAK960-24, which was made by Sercel Inc., and outputs seismic data onto 3590E tapes with SEG-D 8048 format. We set system delay to be 150ms. The sampling rate was 4ms and the record length was 15s. The Differential GPS (DGPS) was used for the positioning. We adopted StarFire system as a main positioning system and SkyFix as a backup. The accuracy is reported to be about 0.4 m in StarFire and 5 m in SkyFix. As navigation software for seismic data acquisition, we used the SPECTRA made by Concept Inc. Positioning data collected from StarFire as well as SkyFix were sent to RTNμ (a network interface made by Concept Inc.) via a terminal server connected to LAN in the vessel. The RTNμ obtains time signals of DGPS (StarFire) from the original antenna. Then, the navigation data is sent to the PC Linux machine, on which the SPECTRA was installed and displayed. Shot times and Shot Point (SP) are set on the SPECTRA and then a trigger signal is sent to the recording system and the gun controller (GCS90), as follows.

First, a system-start-signal generated from the SPECTRA is sent to the recording system via the RTNμ, and soon after, the recording system send back a reply signal to the SPECTRA when the system is ready for recording. Second, the SPECTRA sends a trigger signal to the gun controller and the recording system sends a data-acquisition-start-signal to the streamer cable. The gun controller sends back an internal-time-break-signal to the RTNμ and recording system, and also sends trigger-signals to the eight airguns as shooting orders just after receiving the trigger signal from the SPECTRA. At the same timing with shot, the gun controller starts to gather both position data of the airgun sub-arrays from the airgun positioning system (RGPS) and first breaks of near-field shot records from monitor hydrophones nearby guns. Then seismic data are transmitted from the active modules to the recording system and position data of the streamer are sent from the depth controllers (so-called birds). After that, the position data of both the airgun and streamer cable are stored into the SPECTRA via the RTNμ and are also sent to the recording system. Finally, the seismic data are output to a tape drive and recorded on 3590E tapes. The recording system and gun controller are connected via RTNμ as shown by Figure 5.

4. Example of data

4.1 Wide-angle seismic data along the Minami-Ioujima ridge (KR0601)

All seismic section shown in Fig. 5 are plotted with 3 – 12 Hz band-pass filter, predictive deconvolution filter and 1s automatic gain control.

Site01: Quality of data is relatively good. First arrival can be traced up to 300 km offsets. This section is characterized by faster apparent velocity at near offset. The apparent velocity of ~ 8 km/s is observed from only 10 km offsets. This implies remarkably thin crust at the southwestern end of the ridge. Although clearer later reflections are hardly observed, a strong amplitude between 100 and 200 km offset may correspond a sub-moho reflection.

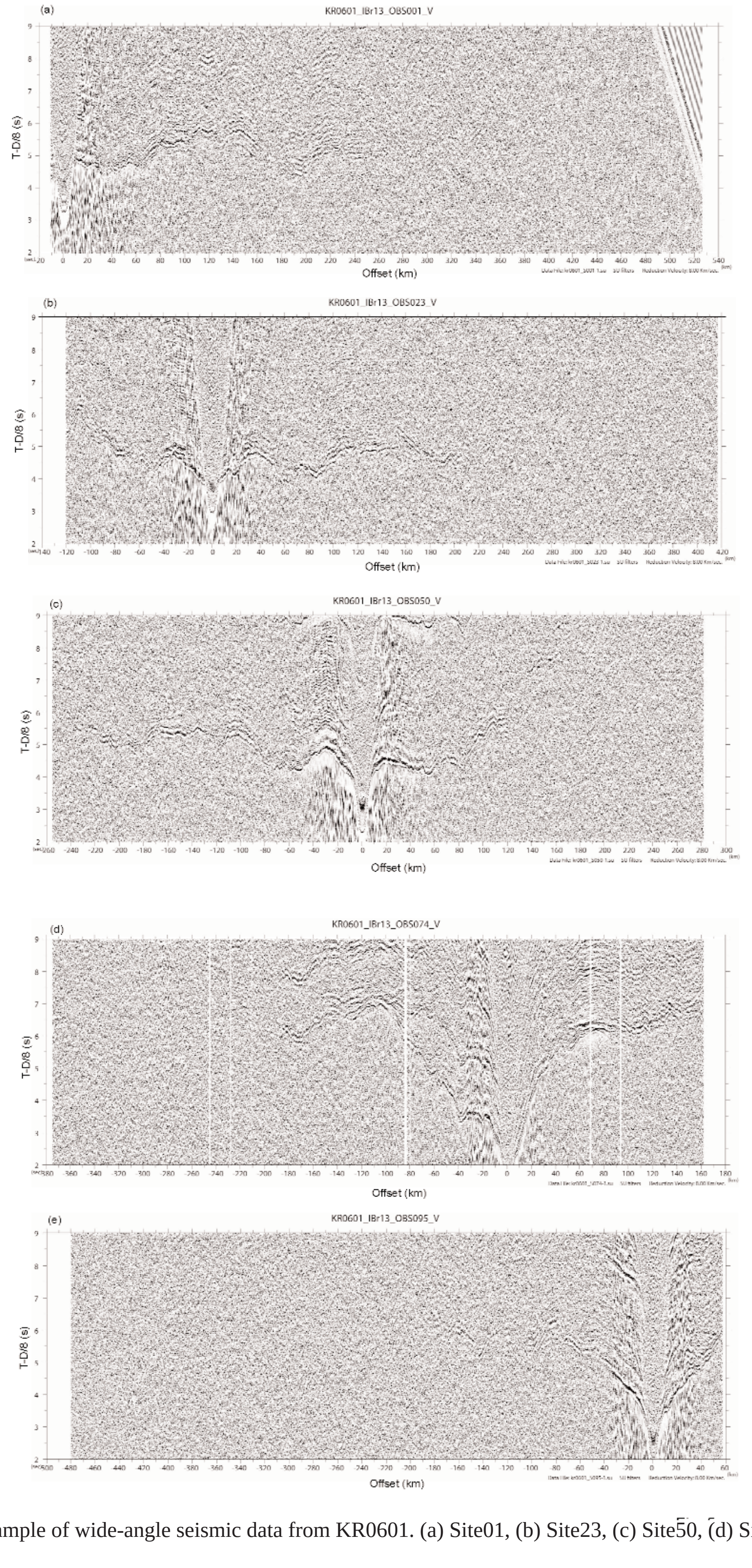

Figure 5: Example of wide-angle seismic data from KR0601. (a) Site01, (b) Site23, (c) Site50, (d) Site74, (e) Site90.

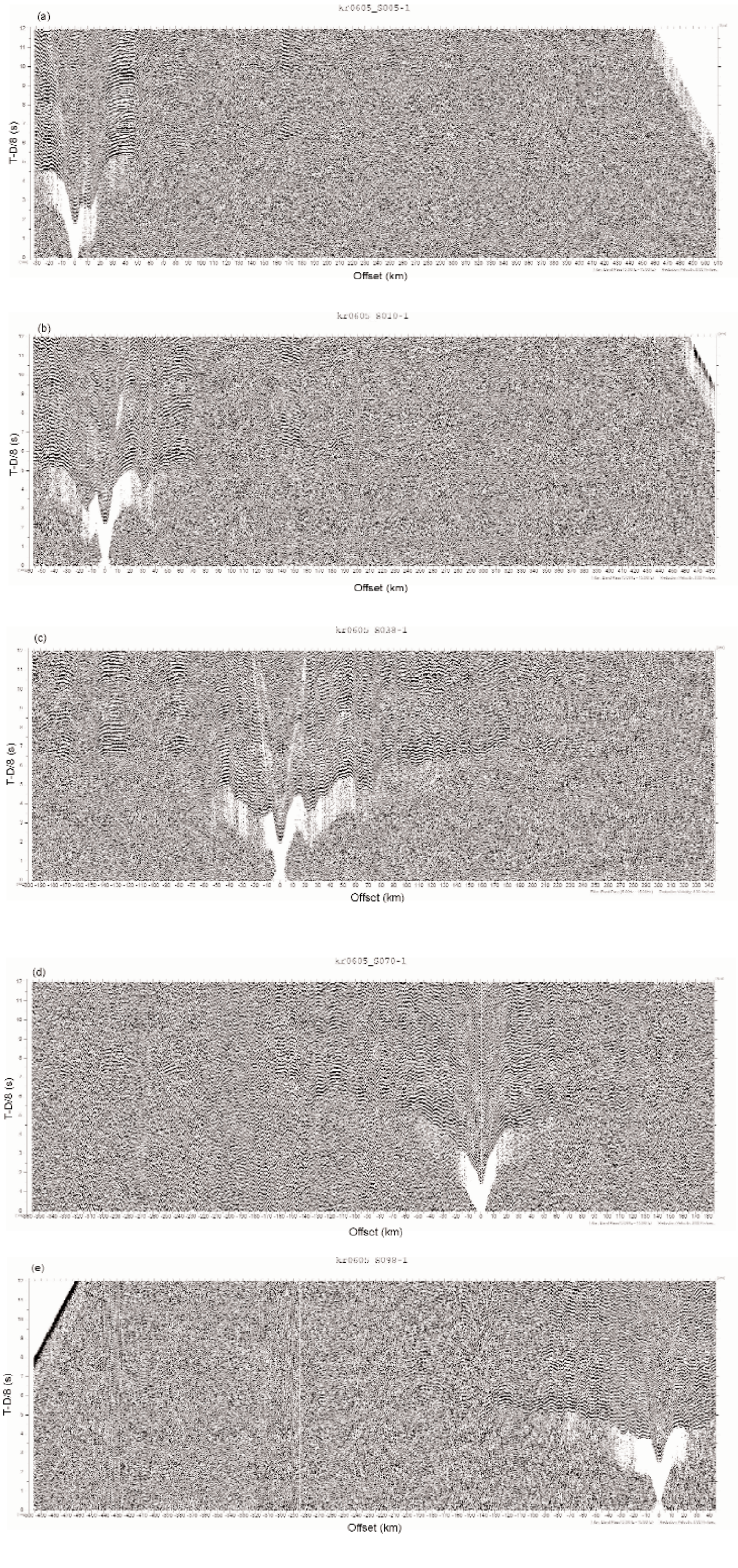

Figure 6: Example of wide-angle seismic data from KR0605. (a) Site05, (b) Site10, (c) Site38, (d) Site70, (e) Site98.

Site23: We can trace first arrivals more than 200 km offset from this record section. In contrast with the data observed at Site01, first arrivals showing apparent velocity less than 6 km/s are observed at shorter offset (~ 40 km offsets). Clear later reflection arrivals are recognized between 160 – 200 km offsets at 4.5 – 5.5 s. Those indicate an existence of a sub-moho reflector. Since the reflection from sub-moho reflector is also observed at Site01, this reflector may extend at the southern part of the ridge.

Site50: First arrivals can be traced more than 250 km offset at the southwestern part of the profile, while they can be traced up to only 160 km offset at the northeastern part. Characters of the first arrivals in the southwestern part are similar to Site 23. This indicates simple flat structure at least in the southwestern half of the profile. The apparent velocity of the first arrival from the northeastern part is distorted due to abrupt change of water depths. Stronger amplitude observed at 90 – 130 km offsets and 140 – 170 may indicate reflection phases.

Site74: This record section shows remarkably different character from the previous record sections. The most significant difference is longer observable range of slower apparent velocity phases (> 6 km/s). Those phases are observed up to 100 km offset at the southwestern part and 60 km offsets at the northeastern part. Since this OBS is located at near the top of the arc, those longer observable range indicate significantly thicker crust beneath the arc than the southern part of the ridge. Later arrivals observed at 70 – 15 km offsets (7 s) at the southwestern part and 60 – 120 km offsets (6.5 s) at the northeastern part are interpreted as reflections from the base of the crust beneath the arc. We can estimate exact thickness of the arc crust by further processing.

Site95: Observable ranges of slower apparent velocity less than 6 km/s is shorter than that of Site74. This implys thinning of the crust toward forearc. A weaker amplitude phase observed more than 80 km offsets may correspond mantle reflection phase. Although later reflection phases are not very obvious, larger amplitude phases at 40 – 70 km and 80 – 120 km offset may represent reflection phases.

4.2 Wide-angle seismic data across the Nishi-shichito ridge (KR0605)

Seismic sections shown here are only process with 5 – 15 Hz band-pass filter and automatic gain control of 2 s as preliminary processing (Fig. 6).

Site05: Since the profile is designed for across the ridges, apparent velocities of first arrivals are strongly affected by variation of water depth along the profile (e.g., 5 – 20 km offsets and 50 – 70 km offsets). First arrivals observed farther than 30 km, however, roughly show apparent velocity of 8 km/s which may be refraction arrival from mantle. Stronger amplitude at 80 – 110 km and 160 – 200 km offset may be reflections phases.

Site10: This record section shows good quality of arrivals. We can trace the signal up to 250 km offset. The slower apparent velocity phase less than 7 km/s observed till 70 km offset is interpreted as crustal refraction phases. Later arrivals at 50 – 90 km and 14 – 200 km offsets may be reflections from the base of crust and sub-moho reflector, respectively.

Site38: This record section also shows good quality data. First arrival can be traced more than 250 km offset. Slower apparent velocity phases less than 7 km/s are observed 120 km at the south and 80 km at the north. They shows longer offsets than those observed at Site10. This implies that crust becomes thicker toward the middle of the profile from the north. Strong amplitude later arrivals observed from 80 km offset at both side are interpreted as reflections from the base of crust. Another later arrival observed at 120 – 150 km offset may correspond to reflection from a sub-moho reflector at the northern part of the profile.

Site70: Observable range of slower apparent velocity phase (< 7 km/s) becomes shorter in this section than those of site 38. This indicates crustal thinning toward the south from the middle of the profile. Later arrivals observed at 40 – 60 km offset may be reflection from the base of curst.

Site98: First arrivals interpreted as crustal refraction phases are observed up to 130 km offset. Apparent velocity of those phase seem to be firster than the previous sections, but this may be cause of variation of water depth. Due to reverberation of the first arrival, onset of later reflection arrivals are not clearly recognized, however, wave-train observed between 50 and 120 km offset seems to show reflections from the base of crust.

4.3 Multichannel reflection seismic data

Raw MCS reflection data are processed on board for the purpose of quality control and preliminary interpretation of tectonic structures in the study areas. The onboard data processing was conducted preserving relative amplitudes under the conventional processing scheme, as shown in Figure 7, which contains noisy-trace editing, 5-100 Hz band-pass filtering, deconvolution with a 28-ms-length predictive distance and a 250-ms-length operator, amplitude compensation by T^2 (T is two way traveltime), velocity analysis, multiple suppression by radon transform, muting, CDP stacking and post-stack time migration.

Figure 8 show results of on-board processing A01

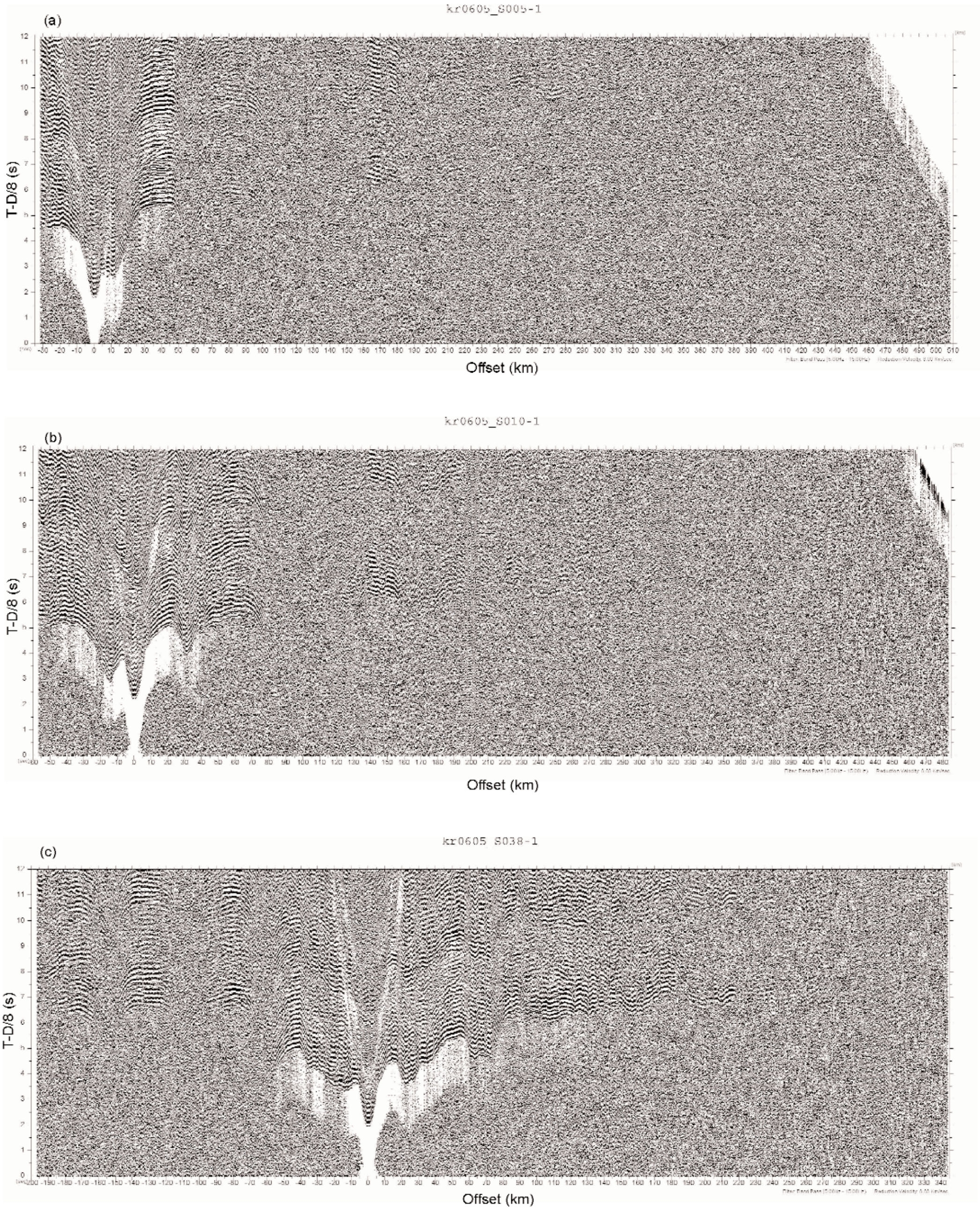

Figure 7: Flow chart of on-board processing multichannel data

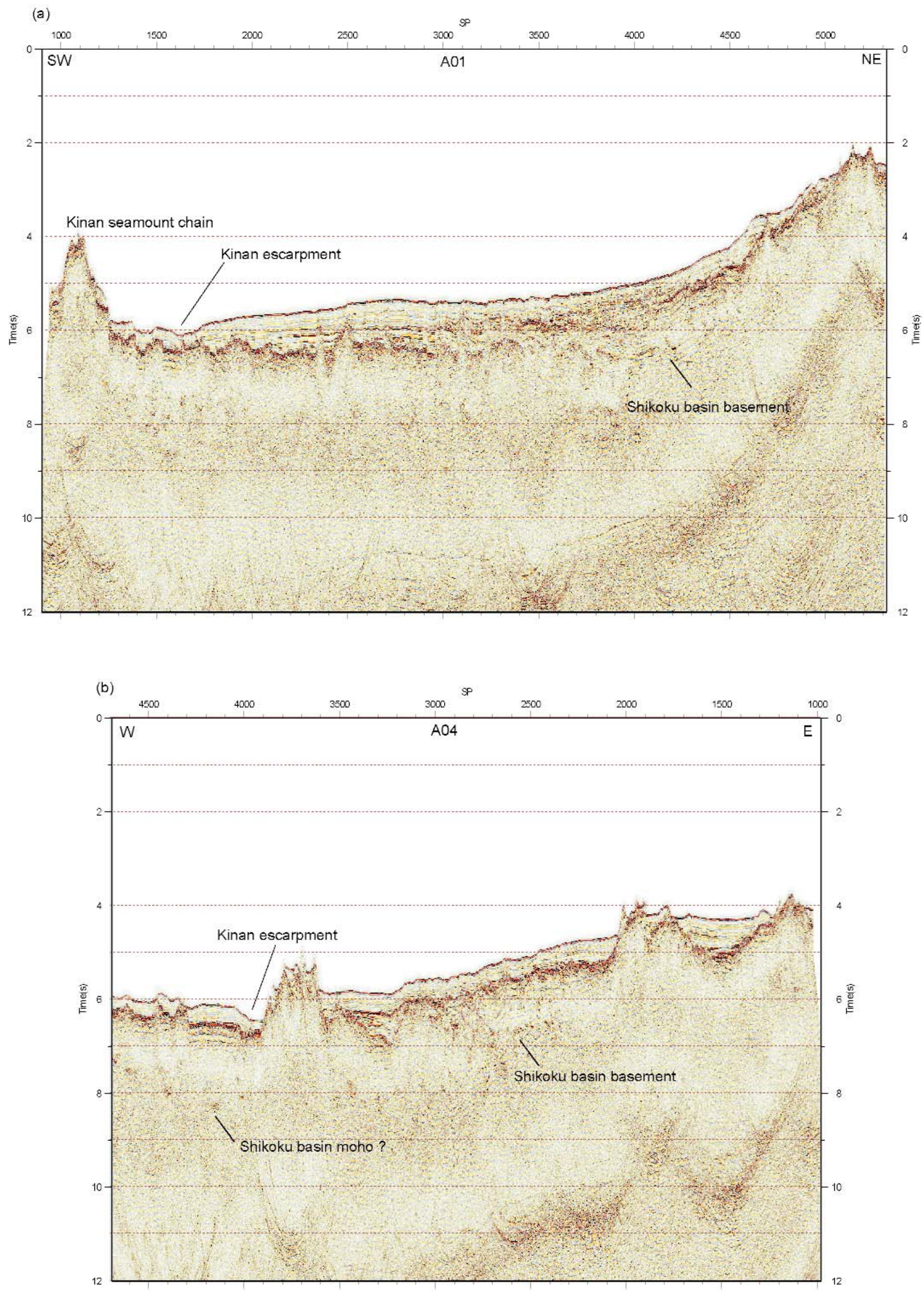

Figure 8: Results of on-board processing multichannel data. (a) Time migration of A01, (b) Time migration of A04.

and A04. Both profiles are located from the Kinan seamount chains to the Nishi-shitito ridges through the Kinan escarpment, A01 was take more parallel to the strike of across-arc seamount chains. The most characteristic structure in both sections is that the basement of the Shikoku basin is imaged beneath the basement extending from the across-arc seamount chains. We can recognize this character clearer along A01. In Fig.8, the Shikoku basin basement is traced at SP4300. The basement form the across-arc seamount chains cover the Shikoku basin basement till SP2500. This character indicates that the across-arc seamount chains were formed on the Shikoku basin crust, and a boundary between the Shikoku basin and the Oligocene arc may be situated around eastern end of the across-arc seamount chains. It notes that the base of the Shikoku basin crust is sporadically observed along both profiles. Although the Kinan escarpment has been suggested as a sort of structure boundary, any distinct structural variation beneath the basement can not be observed in A01.

5. Summary

We have conducted two active source seismic cruises across and along the across-arc seamount chains in the Izu-Bonin arc by R/V Kairei in 2006, KR0601 and KR0605. They are the first cruises in which more than 100 OBS were handled by R/V Kairei. We have successfully acquired wide-angle seismic data during both cruise and multichannel reflection data during KR0605. The observed wide-angle seismic data acquired along the Minami-Ioujima ridge (KR0601) indicate flat and thin crust beneath the ridge. The wide-angle seismic data across the across-arc seamount chain in the Izu arc show the north – south structural variation (i.e. thicker crust in the north and thinner crust in the south). We found that the basement of the Shikoku basin is continued under the across-arc seamount chain. This indicates that a boundary between the Shikoku basin crust and the Oligocene arc crust is situated around eastern end of the across-arc seamount chains.

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