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S t e a 🖡 🕤 a 🍬 c_r a a t_a Ata t_a ct ta_- S Oc ra ac_r atr 1 T b. Steen a, b, *, Mate F a a, J Rec e^{c} , E C. Hat Bia A. Har, Cata , Jaa , Cata , Pa ^a GEOMAR, Helmholtz Centre for Ocean Research Kiel, Wischhofstr. 1-3, 24148 Kiel, Germany ^b SOEST, University of Hawaii at Manoa, 1680 East-West Rd., Honolulu, HI 96822, USA °Department of Earth Sciences, University of Bristol, Wills Memorial Building, Bristol BS8 1RJ, UK COAS, Oregon State University, 104 Ocean Admin. Bldg., Corvallis, OR 97331, USA

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Stat					DebCe	D_r tı ()	T_r _rat _r (°C)	Saĭ• i•t	₽ _N	Ε (2σ)	N (/	8 _H	Ε (2σ)	H ()	/
<u>S1</u>	34° 53.15'	S	16° 40.70'	Е	F. a	5	21.03	35.47	-18.9	0.3	24.2			0.06	
97	36° 59.60'	S	12° 45.40	Е	CTD	100	18.23	35.55	-15.9	0.4					
S2	38° 48.00'	S	11° 35.80'	Е	F. a	5	17.53	34.92	-11.0	0.3	6.7			0.04	
101	42° 20.60'	S	8° 59.20'	Е	CTD	75	10.21	34.55	-9.7	0.4	8.6				
104	47° 39.80'	S	4° 16.20'	Е	CTD	75	6.41	33.72	-7.9	0.4	8.2				
105	47° 39.00'	S	4° 16.60'	Е	F. a	5	6.50	33.71	-7.9	0.3	7.4			0.08	
113	52° 59.80'	S	0° 02.00'	Е	CTD	75	1.22	33.79	-7.9	0.4	16.1				
113	52° 59.80'	S	0° 02.00'	Е	CTD	150	0.20	34.02	-8.0	0.4	15.0				
116	54° 21.00'	S	0° 01.00'	Е	F. a	5	1.04	33.80	-8.0	0.3	15.8	4.5	0.8	0.18	
133	59° 14.00'	S	0° 02.00'	Е	F. a	5	0.21	33.95	-8.6	0.3	18.2			0.19	
142	62° 20.00'	S	0° 00.00'	Е	F, a	5	0.53	33.94	-8.6	0.3	17.3	5.0	0.8	0.11	
151	65° 19.00'	S	0° 00.00'	Е	F. a	5	-0.18	33.97	-8.5	0.3	17.3	4.9	0.8	0.18	
154	70° 34.50'	S	8° 07.38'	W	CTD	135	-1.69	34.02	-9.9	0.4	19.4			0.22	
156	67° 08.00'	S	0° 24.00'	Е	F. a	5	-0.67	33.97	-8.6	0.3	19.5	3.0	0.8	0.25	
161	66° 29.20'	S	0° 00.00'	Е	CTD	100	0.77	34.64	-8.7	0.4	17.9			0.40	
GN	68° 31.80'	S	4° 39.00'	W	F. a	5	-1.18	33.84	-8.8	0.3	16.8	3.4	0.8	0.20	
S3	69° 02.00'	S	15° 42.00'	W	S ,	5	_	—	-8.6	0.3	16.9	4.0	0.8	0.16	
186	69° 03.00'	S	17° 25.00'	W	CTD	25	-1.84	33.93	-8.4	0.3	17.2	4.3	0.8	0.20	
191	67° 21.00'	S	23° 38.00'	W	CTD	25	-1.85	34.12	-8.5	0.3	18.5	4.3	0.8	0.21	
S4	65° 34.00'	S	36° 46.00'	W	S,	5	-1.44	34.15	-9.0	0.3	18.5			0.18	
S5	64° 59.00'	S	42° 00.00'	W	S,	5	-1.55	33.91	-8.4	0.3	18.3	2.8	0.8	0.16	
S6	64° 20.00'	S	46° 04.40'	W	S _r	5	-1.76	33.25	-8.6	0.3	18.1	3.8	0.8	0.22	
210	64° 02.80'	S	48° 15.40'	W	CTD	25	-1.83	33.79	-8.5	0.3	18.3	3.3	0.8	0.27	
222	63° 21.00'	S	52° 51.00'	W	CTD	25	-1.82	34.08	-8.9	0.3	19.9	3.7	0.5	0.25	
222	63° 21.00'	S	52° 51.00'	W	CTD	50	-1.82	34.10	-8.9	0.4	21.2			0.29	
222	63° 21.00'	S	52° 51.00'	W	CTD	100	-1.58	34.37	-8.9	0.4	19.9			0.30	
222	63° 21.00'	S	52° 51.00'	W	CTD	180	-1.22	34.49	-8.7	0.4	20.4			0.32	
222	63° 21.00'	S	52° 51.00'	W	CTD	280	-0.90	34.54	-8.7	0.4	21.3			0.35	
222	63° 21.00'	S	52° 51.00'	W	CTD	480	-0.90	34.56	-9.1	0.3	22.5	3.9	0.8	0.34	
223	63° 17.00'	S	53° 13.00'	W	CTD	25	-1.82	34.18	-8.3	0.3	21.1	4.2	0.9	0.31	
S 7	62° 08.00'	S	57° 31.00'	W	مر S	5	1.04	34.06	-4.0	0.3	22.6	6.1	0.5	0.38	
S 8	60° 03.00'	S	55° 24.00'	W	مر S	5	1.78	33.85	-7.2	0.3	14.3	3.1	0.9	0.20	
230	60° 06.00'	S	55° 16.40'	W	CTD	50	0.79	34.17	-6.9	0.4	18.9			0.31	
230	60° 06.00'	S	55° 16.40'	W	CTD	150	0.57	34.34	-6.4	0.4	19.9			0.35	
241	57° 37.20'	S	60° 53.80'	W	CTD	50	2.84	33.79	-8.4	0.4	11.8			0.17	
244	56° 53.80'	S	62° 28.00'	W	CTD	25	5.38	33.92	-8.2	0.4	10.2			0.12	
244	56° 53.80'	S	62° 28.00'	W	CTD	50	5.38	33.92	-8.2	0.4	9.6			0.09	
250	55° 45.50'	S	64° 26.20'	W	CTD	150	3.64	34.02	-8.2	0.4	9.7				
DRA001 ^a	55° 07.00'	S	65° 33.04'	W	CTD	50	8.32	33.74	-5.7	0.6	8.5				
DRA006 ^a	55° 45.00'	S	64° 30.00'	W	CTD	20	5.10	33.90	-8.6	0.3	8.9				
DRA030 ^a	58° 52.00'	S	58° 18.00'	W	CTD	20	2.50	33.89	-8.2	0.5	14.7				
DRA052 ^a	61° 50.00'	S	55° 26.00'	W	CTD	31	_		-6.3	0.3	21.4				
DRA062 ^a	60° 39.00'	S	55° 47.00'	W	CTD	20	0.62	34.33	-7.2	0.4	17.7				

^aSa _r ANTXXIII/3 (_ertrt).

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- a F. tT., G the S., H. S., R M., F.a M. a Hana A. (2007) G ba a start to trance Earth Planet. Sci. Lett. 259, 432-441.
- a Fert T. a Par FK.Grtacrietreaban and at (2012) GEOTRACES treaban it ra arratirer rtina atra air and atr Patlitte and airte air Limmol.
- Oceanogr. Methods 10, 234–251. V., t J. D., Pate, tt P. J., Bree, t-T t J. a Aba, F. (1999) R. a. b.t. L. H. a S. N. t. c.
- (1999) R. a b. b.t. e. L. -H. a S. -N i t. c. t. i b. . ba ta t. . Earth Planet. Sci. Lett. 168, 79–99.

- White W., Pate set J. a B. Ot a D. (1986) H = t s at a M size set a a t_{s} c a a t_{s} c H = a at set Earth Planet. Sci. Lett. **79**, 46-54.
- Whit to, III, T. (1980) Z at a <u>r</u>to to to A tacked c <u>a</u> c <u>r</u>tat D a <u>r</u>Pa a <u>r</u> Deep Sea Res. Part A. Oceanogr. Res. Papers 27, 497-507.
- Z. a B., P. c., D., F. a M., R. c. J., L. c. D. a Ha a A. (2009a) T. a t. t. c. Pack-c Oc.a at. Geochim. Cosmochim. Acta 73, 91-101.
- Ze _r a B., P cr D., F a M., A _r P. S., Ba a a M., L cr D.-C. a Ha a A. N. (2009b) Ha b t r A chc O cra at r. Geochim. Cosmochim. Acta 73, 3218-3233.

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