

## 34. DATA REPORT: COMPOSITIONS OF FLUIDS AND AUTHIGENIC PHASES IN SEDIMENTS OF THE NANKAI TROUGH ACCRETIONARY COMPLEX<sup>1</sup>

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### ABSTRACT

Pore fluid and sediment chemical and isotopic data were obtained at ODP Site 808, western Nankai trough, Japan. The isotopic data reported here (Tables 1, 2, 3, 4) were carried out in our shore-based laboratories to complement the shipboard inorganic geochemical data published in Shipboard Scientific Party (1991). The data include: hydrogen, oxygen, and strontium isotopic compositions of the pore fluids, carbon and oxygen isotopic compositions of biogenic and authigenic calcites, and preliminary mineralogical compositions of the authigenic precipitates in veins and in tubular-cylindrical structures, observed in the sediments between 870 and 1080 mbsf. These data do not support active pervasive fluid flow at the décollement zone nor at the frontal thrust. They do, however, support pervasive active lateral fluid flow above and particularly below the décollement.

### INTRODUCTION

Sediments entering subduction zones typically have porosities of approximately 50% ± 10%, while the porosities of subaerially exposed accretionary complex sediments are less than 5%–10%. Large scale fluid expulsion accompanies this major porosity reduction. Internal processes, such as thermal dehydration and decomposition of hydrous minerals, provide additional fluids to the system. While moving through the sediments, the fluids interact with them and transport heat and solutes. Exchange reactions occur between the sediments and the fluids and modify the chemical and isotopic compositions of the fluids and diagenetic solids. Unravelling the origins of these complex, diagenetically altered fluids requires extensive chemical and isotopic analyses of both the pore fluids and of the sediments, especially of the diagenetic precipitates.

### MATERIALS AND METHODS

All pore fluids analyzed were obtained by routine shipboard squeezing of whole-round sediment samples, almost immediately after retrieval. The sediments were squeezed in both titanium and stainless-steel squeezers, at ambient temperature and at pressures of 2000–3000 psi (140–210 kg/cm<sup>2</sup>). Occasionally, for short periods of time, the most indurated samples were squeezed at 3500 psi (245 kg/cm<sup>2</sup>). The Ti squeezers were provided by D. Froelich from Lamont-Doherty Geological observatory. No systematic differences were observed in the chemistry of the fluids obtained by the two different squeezers. Samples were analyzed on board ship for a range of constituents and were supplemented by shore-based analysis summarized in Tables 1 through 4. Oxygen, hydrogen, carbon, and strontium isotopic compositions were determined by mass spectrometry. Stable isotopes in calcites were determined using the method of McCrea (1950). The accuracy was 0.04‰ and the precision 0.07‰ for carbon and 0.08‰ for oxygen. Isotopic compositions of water samples were determined using the method of Bottinga and Craig (1969). Precisions were 0.80‰ for D/H and 0.10‰ for oxygen. Sr isotopes were determined as previously described, for example by Elderfield et al. (1982). Precisions

are shown in Tables 1 and 2. Measured <sup>87</sup>Sr/<sup>86</sup>Sr ratios were normalized to <sup>87</sup>Sr/<sup>86</sup>Sr = 0.1194, but have not been normalized to a particular value for a standard; values of 0.71027 for NBS 987 and 0.70916 for modern seawater have been obtained.

The mineralogy of the authigenic minerals described in Kastner et al. (this volume) was determined by routine X-ray diffraction (XRD) methods and by scanning electron microscopy (SEM).

### Pore Fluid Sr Isotopic Composition of Dried-up Solid Samples

When sediment porosities are low, ≤30%, no pore water is recovered by squeezing the sediment, even from 20–30 cm long whole round samples. We therefore were unsuccessful in recovering a pore water sample from Core 808C-69R, the décollement core. In order to test the feasibility of leaching such “dry” sediments with ultra-pure H<sub>2</sub>O to extract Sr from pore waters without any Sr isotopic fractionation and without sampling exchangeable Sr from solids, we conducted the following experiments:

The pore fluids and the leached Sr of the following dried sediment samples: 808C-94R-1, 0–35 cm, and 808C-99R-1, 0–30 cm, were analyzed for their <sup>87</sup>Sr/<sup>86</sup>Sr isotopic compositions. These two samples were chosen for the test because of the very large differences between the Sr isotopic compositions of the squeezed on-board pore fluids and of the bulk sediments (Table 1). Based on lengthy testings in our laboratory, these samples were “leached” with ultra-pure H<sub>2</sub>O at room temperature for 3–5 min. The results for Sr isotopes are given below. “Leaching” dry sediments for longer times or for short times but at moderately elevated temperatures, of 30°–60°C, is not recommended. Some Sr is being extracted from the solids in the latter pretreatments of sediment samples.

Sample	<sup>87</sup> Sr/ <sup>86</sup> Sr		Bulk sediment
	Squeezed pore water	Leach with ultra-pure H <sub>2</sub> O	
808C-94R-1, 0-35 cm	0.708563 ± 17	0.708625 ± 20	0.715178 ± 17
808C-99R-1, 0-30 cm	0.707891 ± 16	0.707961 ± 19	0.175663 ± 18

The effects of either longer “leaching” times even at room temperature, and leaching at 35°C are summarized below for Sample 808C-68R-1, 5–10 cm:

<sup>1</sup> Hill, I.A., Taira, A., Firth, J.V., et al., 1993. *Proc. ODP, Sci. Results*, 131: College Station, TX (Ocean Drilling Program).

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	$^{87}\text{Sr}/^{86}\text{Sr}$
Squeezed pore water	0.707622 ± 20
"Leached" pore water, room temperature, 1 hour	0.707693 ± 18
"Leached" pore water, 35° C, 15 minutes	0.707738 ± 19

On the basis of these plus additional tests, we proceeded to analyze the décollement Sample, Core 69R-1, for its pore water  $^{87}\text{Sr}/^{86}\text{Sr}$  ratio. The result is given in Tables 1 and 2. This value was obtained by "leaching" two separate subsamples of the composite sediment sample (954–963 mbsf) in ultra-pure  $\text{H}_2\text{O}$  at room temperature for 3 min. The data from the two leaches are practically identical:

Analysis 1: 0.707764 ± 18

Analysis 2: 0.707760 ± 20

The above tests and Sr isotopic results clearly indicate that even "dry" sediment samples can be reliably analyzed for their pore water Sr isotopic composition.

**Table 1. Chemical and Sr isotopic compositions of pore fluids from the Nankai trough, Site 808.**

Core, section, interval (cm)	Depth (mbsf)	Cl (mM)	Sr ( $\mu\text{M}$ )	$^{87}\text{Sr}/^{86}\text{Sr}$	$\sigma$
131-808C-					
3H-5, 140–150	23	572	60	0.708711	22
5X-1, 88–103	151	576	82	0.708592	20
19X-1, 135–150	284	580	103	0.708367	29
11R-2, 50–63	397	581	107	0.708348	18
27R-5, 123–150	557	588	135	0.707723	21
28R-2, 124–150	562	592	129	0.707797	22
53R-4, 120–150	805	512	116	0.707099	23
55R-2, 120–150	822	514	202	0.707069	16
60R-4, 116–150	873	475	262	0.707121	16
61R-2, 115–150	879	474	258	0.707164	16
64R-1, 115–150	907	481	282	0.707281	20
66R-2, 115–150	928	468	284	0.707499	22
68R-1, 5–10	944	476	298	0.707622	20
<sup>a</sup> 69R-1, composite sample	954–963	–	–	0.707764	18
70R-4, 0–35	968	476	302	0.707798	21
71R-2, 120–150	976	471	277	0.707812	18
77R-4, 0–35	1035	465	302	0.708084	21
79R-2, 0–35	1050	453	271	0.708183	18
84R-1, 120–150	1093	466	283	0.708370	24
86R-2, 115–150	1109	447	299	0.708408	16
<sup>b</sup> 94R-1, 0–35	1185	466	372	0.708563	17
<sup>c</sup> 99R-1, 0–30	1234	512	500	0.707891	16

<sup>a</sup> Wash with ultrapure water of carefully cleaned composite sample.

<sup>b</sup> Solid residue 0.715178 (17).

<sup>c</sup> Solid residue 0.715663 (18).

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\* Abbreviations for names of organizations and publication titles in ODP reference lists follow the style given in *Chemical Abstracts Service Source Index* (published by American Chemical Society).

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**Table 2. Sr Isotopic ratios and concentrations of pore fluids from the Nankai trough, Site 808.**

Core, section, interval (cm)	Depth (mbsf)	$^{87}\text{Sr}/^{86}\text{Sr}$	$\sigma$	$\text{Sr}^a$ ( $\mu\text{M}$ )	$\text{Sr}^b$ ( $\mu\text{M}$ )	$1/\text{Sr}^c$	$1/\text{Sr}^d$
131-808C-							
3H-5, 140–150	23	0.708711	22	60	60	0.0167	0.0167
5X-1, 88–103	151	0.708592	20	82	<sup>e</sup> (83)	0.0122	(0.0120)
19X-1, 135–150	284	0.708367	29	103	(103)	0.0097	(0.0097)
11R-2, 50–63	397	0.708348	18	107	107	0.0093	0.0093
27R-5, 123–150	557	0.707723	21	135	135	0.0074	0.0074
28R-2, 124–150	562	0.707797	22	129	(151)	0.0078	(0.0066)
53R-4, 120–150	805	0.707099	23	116	(108)	0.0086	(0.0093)
55R-2, 120–150	822	0.707069	16	202	202	0.0050	0.0050
60R-4, 116–150	873	0.707121	16	262	262	0.0038	0.0038
61R-2, 115–150	879	0.707164	16	258	258	0.0039	0.0039
64R-1, 115–150	907	0.707281	20	282	282	0.0035	0.0035
66R-2, 115–150	928	0.707499	22	284	284	0.0035	0.0035
68R-1, 5–10	944	0.707622	20	298	(325)	0.0034	(0.0031)
69R-1, composite sample	954–963	0.707764	18	–	–	–	–
70R-4, 0–35	968	0.707798	21	302	302	0.0033	0.0033
71R-2, 120–150	976	0.707812	18	277	277	0.0036	0.0036
77R-4, 0–35	1035	0.708084	21	302	302	0.0033	0.0033
79R-2, 0–35	1050	0.708183	18	271	271	0.0037	0.0037
84R-1, 120–150	1093	0.708370	24	283	283	0.0035	0.0035
86R-2, 115–150	1109	0.708408	16	299	299	0.0033	0.0033
<sup>f</sup> 94R-1, 0–35	1185	0.708563	17	372	372	0.0027	0.0027
<sup>g</sup> 99R-1, 0–30	1234	0.707891	16	500	500	0.0020	0.0020

<sup>a</sup> Values from atomic absorption measurements.

<sup>b</sup> Values from atomic absorption measurements except for bold values, measured by isotope dilution.

<sup>c</sup> Calculated from concentration values measured by atomic absorption.

<sup>d</sup> Calculated from concentration values measured by atomic absorption and isotope dilution.

<sup>e</sup> The concentrations in parentheses were analyzed by isotope dilution, the rest by atomic absorption.

<sup>f</sup> Solid residue  $^{87}\text{Sr}/^{86}\text{Sr}$  ratio: 0.715178 (17).

<sup>g</sup> Solid residue  $^{87}\text{Sr}/^{86}\text{Sr}$  ratio: 0.715663 (18).

**Table 3. Oxygen and hydrogen isotopic compositions of pore fluids from the Nankai trough, Site 808.**

Core, section, interval (cm)	Depth (mbsf)	$\delta^{18}\text{O}$ (‰ SMOW)	$\delta\text{D}$ (‰ SMOW)
131-808C-			
3H-5, 140-150	23		-4.4
5X-1, 88-103	151	-2.5, <sup>a</sup> -2.3	-5.7, <sup>a</sup> -5.4
12R-1, 130-150	406	-1.7	
28R-4, 110-150	565	-2.2, <sup>a</sup> -2.2	<sup>a</sup> -6.7
35R-4, 132-150	632	-3.3	-7.2, -7.6
45R-4, 125-150	728	-3.0	
53R-4, 120-150	805	-2.1	-7.5, -9.2
54R-2, 120-150	812		-8.9
55R-2, 120-150	822	-1.9	
61R-2, 115-150	880	-2.0	
64R-1, 115-150	907		-8.8
65R-2, 0-34	917	-1.1	
66R-2, 115-150	928	-0.9	
71R-2, 120-150	976	-0.7	
72R-3, 0-5	986	<sup>a</sup> -0.6	-10.3, <sup>a</sup> -11.3
75R-1, 117-145	1013	-0.7	-9.9, -9.6
77R-4, 0-35	1035	-0.4	-11.7, -11.6
79R-2, 0-35	1050		-10.0
80R-2, 125-150	1061		-10.8, -10.5
84R-1, 120-150	1093	-0.2	-10.4, -10.6
85R-2, 120-150	1101		-10.3
86R-2, 115-150	1111	-0.1	-6.8, -8.4
94R-1, 0-35	1185		-10.4, -10.2
96R-1, 0-36	1204		-7.8, -7.6

<sup>a</sup> Data from Dr. S. Epstein's laboratory.

**Table 4. Oxygen and carbon isotopic compositions of diagenetic calcites from Nankai trough sediments, Site 808.**

Core, section, interval (cm)	Depth (mbsf)	$\delta^{13}\text{C}$ (‰ PDB)	$\delta^{18}\text{O}$ (‰ PDB)	$\delta^{18}\text{O}$ (‰ SMOW)	Comments
131-808C-					
20X-2, 31-33	290	0.87	-0.31	30.54	Bulk sample, in thrust zone
64R-4, 2-4	910	-11.25	-13.25	17.20	Precipitate on slickenside surface
70R-1, 28-30	964	-2.99	-3.10	27.66	Bulk sample
80R-CC, 16-19	1066	-20.81	-14.51	15.91	Clear large (~1 cm thick) calcite vein
80R-CC, 18-19	1066	-21.93	-14.13	16.29	Small clear calcite piece