Teagle, D.A.H., Wilson, D.S., Acton, G.D., and Vanko, D.A. (Eds.)
Proceedings of the Ocean Drilling Program, Scientific Results Volume 206

9. Data Report: Chemical Composition of Unusual Ti Hydrogarnets from the Deepest Volcanic Rocks Cored in ODP Hole 1256D (Leg 206)[1]

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INTRODUCTION

Mid-ocean-ridge basalts recovered from Hole 1256D during Ocean Drilling Program Leg 206 exhibit the effects of various low-temperature (<100°C) alteration processes, including the formation of black or dark green alteration halos adjacent to celadonite-bearing veins. In several samples from the deepest basalts, a Ti-rich hydrogarnet occurs. To our knowledge, such a mineral has never been reported in the oceanic crust. This report presents a brief description and microprobe analyses of this hydrogarnet and associated celadonite. More detailed characterizations of this mineral and a description of its relationship to other secondary minerals will be undertaken in a future study, in an attempt to determine the mineral's formation conditions and its place in the general alteration history of the Hole 1256D basalts.

ANALYTICAL METHODS

Thin sections of hydrogarnet-bearing basalts were studied by optical microscope. Because of its small size, hydrogarnet could not be studied by X-ray diffraction. Electron microprobe analyses of hydrogarnet and celadonite were carried out at Institut Francais de Recherche pour l'Exploration de la Mer (Brest, France) on a Cameca SX50 with a ZAF correction program (Pouchou and Pichoir, 1985). Operating conditions were:

[1] Laverne, C., 2006. Data report: Chemical composition of unusual Ti hydrogarnets from the deepest volcanic rocks cored in ODP Hole 1256D (Leg 206). *In* Teagle, D.A.H., Wilson, D.S., Acton, G.D., and Vanko, D.A. (Eds.), *Proc. ODP, Sci. Results,* 206, 1–6 [Online]. Available from World Wide Web: <http://www-odp.tamu.edu/publications/206_SR/VOLUME/CHAPTERS/005.PDF>. [Cited YYYY-MM-DD]
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Initial receipt: 2 May 2005
Acceptance: 7 October 2005
Web publication: 1 March 2006
Ms 206SR-005

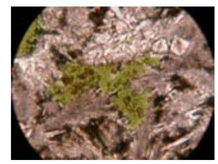
accelerating voltage = 15 kV, specimen current = 15 nA, spot size = 1 µm, count time = 6 s. The standards used for the various elements (in parentheses) are forsterite (Mg), Fe_2O_3 (Fe), albite (Na), Al_2O_3 (Al), NiO (Ni), apatite (P), Cr_2O_3 (Cr), orthoclase (K), wollastonite (Si and Ca), $MnTiO_3$ (Mn and Ti), topaz (F), and vanadinite (Cl). The precision of the method used is <0.5% of the measured concentration.

RESULTS

The study of thin sections by optical microscope reveals the presence of very pale brown, small (5–20 µm) rounded crystals of hydrogarnet. These crystals are associated with celadonite filling vesicles and miarolitic voids or replacing olivine microcrystals in dark green alteration halos adjacent to celadonitic veins (Fig. **F1**), whereas the host rock adjacent to the alteration halos is hydrogarnet free.

The analyzed hydrogarnet is composed mostly of SiO_2 (33–36 wt%), TiO_2 (23–25 wt%), CaO (22–24 wt%), and FeO^t (9–13 wt%) (Table **T1**), suggesting a composition of schorlomite, a Ca-, Ti-, and Fe-rich andraditic garnet. Oxide totals <100 wt% suggest the presence of (OH), Fe^{3+}, or other chemical elements (Table **T1**). The K indicated in the chemical analyses might result from contamination of the X-ray spectrum by potassium in the surrounding celadonite or microinclusions of celadonite in the hydrogarnet. Future studies will address this and other details relating to the composition of the hydrogarnet. The compositions of celadonite of the hydrogarnet-bearing samples are given in **Alt and Laverne** (this volume). Table **T2** presents some representative analyses of this celadonite.

F1. Hydrogarnet and celadonite, p. 4.



T1. Chemical analyses of hydrogarnet, p. 5.

T2. Chemical analyses of celadonite, p. 6.

ACKNOWLEDGMENTS

This research used samples and/or data provided by the Ocean Drilling Program (ODP). ODP is sponsored by the U.S. National Science Foundation (NSF) and participating countries under management of Joint Oceanographic Institutions (JOI), Inc. Funding for this research was provided by grant INSU-CNRS OCEANS 2003-02. Marcel Bohn, Olivier Grauby, and the Leg 206 fellows are thanked for their help. I am grateful to Pietro Marescotti for reviewing this manuscript.

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Figure F1. Hydrogarnet (pale brown granules) and celadonite (green) in a miarolitic void in a dark green halo (Sample 206-1256D-65R-1, 105–109 cm) (plane-polarized light; field of view = 1 mm).

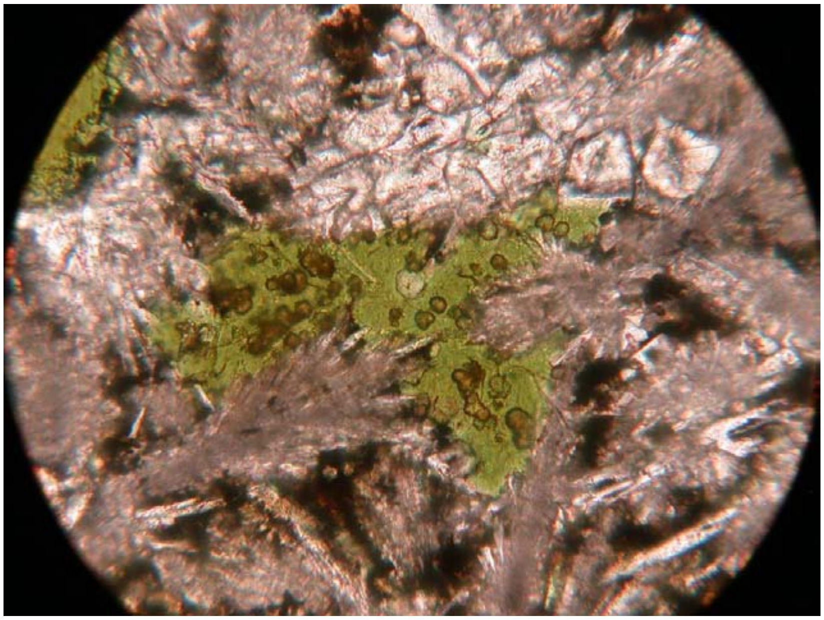

Table T1. Chemical analyses of hydrogarnet, ODP Hole 1256D.

Core, section, interval (cm)	Depth (mbsf)	Laboratory	Analysis number	Major element oxides (wt%)													
				SiO_2	TiO_2	Al_2O_3	CaO	Na_2O	K_2O	FeO	MgO	MnO	P_2O_5	Cl	F	Cr_2O_3	Total
206-1256D-																	
65R-1, 105–109	706.75	B4	136	33.20	22.97	1.62	22.60	0.07	0.94	12.92	0.56	0.00	0.02	NA	NA	0.03	94.92
65R-1, 105–109	706.75	B4	137	33.35	24.95	1.62	24.20	0.07	0.68	9.45	0.39	0.11	0.00	NA	NA	0.00	94.82
65R-1, 105–109	706.75	B4	151	36.15	24.45	2.15	23.27	0.06	1.16	9.33	0.74	0.00	0.05	NA	NA	0.00	97.36
65R-1, 105–109	706.75	B4	154	35.09	24.13	1.72	22.99	0.12	1.05	9.80	0.65	0.00	0.02	NA	NA	0.07	95.64
65R-1, 105–109	706.75	B4	155	34.10	23.53	1.76	23.45	0.07	0.98	10.23	0.75	0.00	0.00	NA	NA	0.04	94.90
65R-1, 105–109	706.75	B5	9	34.45	23.27	1.64	23.68	0.06	0.82	10.19	0.60	0.00	0.00	0.00	0.00	0.02	94.74
65R-1, 105–109	706.75	B5	10	33.83	23.95	1.60	24.08	0.05	0.70	9.63	0.53	0.04	0.05	0.03	0.14	0.08	94.70
65R-1, 105–109	706.75	B5	11	33.62	24.36	1.66	24.19	0.06	0.70	9.51	0.44	0.00	0.00	0.01	0.26	0.00	94.80
65R-1, 105–109	706.75	B5	13	34.20	24.10	1.69	23.48	0.04	0.97	9.96	0.49	0.01	0.00	0.00	0.42	0.00	95.37
65R-1, 105–109	706.75	B5	23	34.14	23.87	1.70	23.32	0.13	0.80	9.58	0.58	0.00	0.02	0.05	0.00	0.00	94.19
65R-1, 105–109	706.75	B5	24	34.06	23.47	1.73	23.09	0.12	0.83	9.68	0.68	0.05	0.04	0.06	0.00	0.00	93.80
65R-1, 105–109	706.75	B5	43	35.34	22.90	1.77	22.89	0.09	1.13	9.53	0.69	0.05	0.00	0.04	0.40	0.03	94.87
65R-1, 105–109	706.75	B5	44	34.01	22.93	1.69	22.58	0.10	1.03	10.63	0.55	0.00	0.02	0.01	0.00	0.10	93.66
67R-1, 47–50	715.27	B4	196	35.86	23.56	1.98	22.36	0.08	1.51	9.90	0.67	0.00	0.00	NA	NA	0.00	95.92
67R-1, 47–54	715.27	B5	26	35.66	22.83	2.02	21.91	0.06	1.52	10.35	0.70	0.00	0.00	0.00	0.37	0.00	95.42
67R-1, 47–54	715.27	B5	27	35.47	23.42	2.00	22.25	0.07	1.29	10.34	0.65	0.00	0.01	0.04	0.07	0.00	95.61

Note: NA = not analyzed.

Table T2. Chemical analyses of celadonite from garnet-bearing Sample 206-1256D-65R-1, 105–109 cm.

Laboratory	Analysis number	Major element oxides (wt%)													
		SiO_2	TiO_2	Al_2O_3	CaO	Na_2O	K_2O	FeO	MgO	MnO	P_2O_5	Cl	F	Cr_2O_3	Total
B5	12	49.54	0.23	4.93	1.74	0.41	5.96	20.64	3.92	0.00	0.00	0.14	0.00	0.00	87.51
B5	14	46.52	0.08	4.79	0.98	0.29	5.88	19.32	5.00	0.00	0.00	0.20	0.29	0.00	83.36
B5	49	45.49	1.07	4.58	2.12	0.18	6.33	21.18	2.73	0.04	0.00	0.19	0.12	0.10	84.12

Notes: Formulas are calculated on the basis of 22 oxygens. All Fe is assumed to be Fe^{3+}.

Table T2 (continued).

Laboratory	Analysis number	Formula (22)											
		Si	Al IV	Al total	Al VI	Mg	Fe	Mn	Ti	Ca	Na	K	VI total
B5	12	3.738	0.262	0.438	0.176	0.441	1.299	0.000	0.013	0.141	0.060	0.573	1.929
B5	14	3.700	0.300	0.449	0.149	0.593	1.282	0.000	0.005	0.084	0.045	0.597	2.028
B5	49	3.643	0.357	0.432	0.075	0.326	1.415	0.003	0.064	0.182	0.027	0.647	1.883