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Title of article The Huntzinger Flow: Evidence of Surface Mixing of the Columbia River Basalt and its Petrogenetic Implications

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see Bulletin v. 98, p. 664 - 677

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TABLE A

Representative Analyses of the Huntzinger Flow From the Pasco Basin

From Borehole DC-14

Oxide and Element / Sample	SiO_2	Al_2O_3	FeO	MgO	CaO	Na_2O	K_2O	TiO_2	P_2O_5
234.1	52.53	17.00	10.33	5.52	8.90	2.20	0.77	1.84	0.52
237.1	52.28	17.12	9.54	4.93	10.39	2.26	0.91	1.80	0.35
240.2	51.73	16.70	9.73	6.47	10.26	2.15	0.59	1.67	0.29
243.5	51.77	15.65	11.06	6.36	9.77	2.27	0.83	1.61	0.31
245.36	52.35	16.35	10.02	6.48	10.32	2.02	0.14	1.62	0.30
245.39	50.78	16.40	9.41	7.29	11.29	1.97	0.78	1.46	0.24
246.6	51.05	16.44	9.73	7.84	10.82	1.87	0.13	1.52	0.21
249.6	50.63	16.41	9.77	8.51	10.70	1.76	0.30	1.34	0.18
255.4	49.87	16.29	9.78	7.97	11.35	2.34	0.38	1.44	0.19
258.2	50.32	16.69	9.83	8.19	10.67	1.97	0.43	1.35	0.19
260.1	50.59	16.45	9.93	8.05	10.93	1.73	0.30	1.42	0.20
264.2	51.03	16.28	10.52	7.32	10.02	2.10	0.56	1.53	0.24
265.8	52.03	15.59	11.36	5.82	8.84	2.53	1.37	1.69	0.35
267.3	51.95	15.27	11.73	6.19	9.02	2.29	1.13	1.65	0.35
281.6	52.73	15.67	10.87	5.48	9.25	2.29	1.23	1.74	0.36
287.7	52.68	15.56	10.75	5.66	9.31	2.27	1.26	1.73	0.37
290.5	52.55	15.82	10.99	5.58	9.33	2.11	1.04	1.75	0.39
294.1	52.85	15.58	10.75	5.37	9.41	2.31	1.14	1.76	0.38
295.4	52.46	15.76	10.84	5.58	9.35	2.26	1.22	1.71	0.37

* % Asotin Composition based upon mixing calculations (see text)

1) Oxides in weight %
2) Trace elements in ppm
3) N.D. - Not determined
4) V, Ni, Rb, Sr, Zr, Ba - XRF; Sc, Cr, La, Ce, Nd, Sm, Eu, Tb, Yb, Lu, Th, Hf, Ta -INAA

Table A

Representative Analyses of the Huntzinger Flow
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Oxide and Element / Sample	MnO	Sc	V	Cr	Ni	Rb	Sr	Zr	Ba	La	Ce	Nd
234.1	0.17	28.8	298	94	85	25	325	213	577	33.7	63	26
237.1	0.22	28.4	275	152	70	24	302	188	787	29.6	53.8	20
240.2	0.20	28.7	260	157	93	26	297	193	382	25.5	47	N.D.
243.5	0.16	28.6	269	144	67	31	280	182	495	27.8	52	N.D.
245.36	0.18	28.5	254	183	99	25	272	165	363	24.4	48	N.D.
245.39	0.18	30.1	246	246	121	11	274	144	137	13.4	28.1	N.D.
246.6	0.17	29.5	259	234	112	9	252	136	153	14.6	28.4	N.D.
249.6	0.17	29.6	251	261	131	15	237	115	619	11.5	22.2	N.D.
255.4	0.17	30.6	256	248	119	21	262	146	141	12.8	25.3	N.D.
258.2	0.15	29.2	249	286	117	16	256	133	184	13.4	25.3	N.D.
260.1	0.18	30.4	257	263	106	17	257	137	114	12.8	27.9	N.D.
264.2	0.19	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
265.8	0.18	27.0	284	100	62	39	267	199	643	31.8	59	20
267.3	0.20	27.6	275	102	80	34	281	211	597	32.2	60	25
281.6	0.18	27.0	270	117	60	34	275	201	612	32.1	62.2	24
287.7	0.19	26.8	277	94	63	43	292	227	589	32.8	61	29
290.5	0.23	26.9	283	102	74	30	280	204	643	32.5	65	24
294.1	0.25	27.8	272	102	64	36	278	205	628	33.8	66	26
295.4	0.23	N.D.	270	N.D.	75	40	283	217	632	N.D.	N.D.	N.D.

* % Asotin Composition based upon mixing calculations (see text)

1) Oxides in weight %
2) Trace elements in ppm
3) N.D. - Not determined
4) V, Ni, Rb, Sr, Zr, Ba - XRF; Sc, Cr, La, Ce, Nd, Sm, Eu, Tb, Yb, Lu, Th, Hf, Ta -INAA

Table A

Representative Analyses of the Huntzinger Flow

Oxide and Element / Sample	Sm	Eu	Tb	Yb	Lu	Th	Hf	Ta	Oxides*	Trace Elements*
234.1	6.71	1.79	0.95	2.85	0.50	4.9	4.7	0.11	23.9	12.2
237.1	6.08	1.72	0.89	2.7	0.51	4.0	4.1	0.12	44.1	0.0
240.2	5.52	1.61	0.86	2.95	0.45	3.5	3.8	0.12	65.2	47.9
243.5	5.73	1.61	0.94	2.9	0.52	3.7	4.1	0.13	35.5	26.8
245.36	5.61	1.55	0.84	2.75	0.36	3.5	3.4	0.14	56.6	53.7
245.39	3.82	1.21	0.46	1.8	N.D.	1.7	2.4	0.09	97.8	96.8
246.6	3.95	1.21	0.63	1.45	0.38	2.0	2.8	0.11	96.8	92.5
249.6	3.37	1.17	0.42	1.85	0.27	1.4	2.2	0.09	100	21.1
255.4	3.78	1.23	0.45	1.9	N.D.	1.4	2.4	0.10	100	94.5
258.2	3.88	1.23	0.59	2.3	N.D.	2.0	2.6	0.12	100	86.7
260.1	3.77	1.23	0.52	2.15	0.30	1.6	2.3	0.11	100	98.3
264.2	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	69.5	N.D.
265.8	6.35	1.72	0.91	3.2	0.49	5.3	4.4	0.12	23.0	0.2
267.3	6.44	1.69	0.94	3.6	0.55	4.8	4.9	0.17	12.0	9.0
281.6	6.40	1.81	0.93	3.35	0.52	4.9	4.6	0.12	9.1	4.6
287.7	6.33	1.67	0.78	3.05	0.51	4.3	4.6	0.14	13.1	8.4
290.5	6.54	1.80	0.76	3.35	0.49	4.5	4.6	0.15	13.6	1.5
294.1	6.53	1.86	0.96	3.25	0.53	5.2	4.9	0.15	9.4	2.8
295.4	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	15.1	4.1

* % Asotin Composition based upon mixing calculations (see text)

1) Oxides in weight %
2) Trace elements in ppm
3) N.D. - Not determined
4) V, Ni, Rb, Sr, Zr, Ba - XRF; Sc, Cr, La, Ce, Nd, Sm, Eu, Tb, Yb, Lu, Th, Hf, Ta -INAA

TABLE B

SUMMARY OF SELECTED RESIDUALS FROM OXIDES AND TRACE ELEMENTS MODELING

Sample	Number of Residuals Beyond Desired Limits (see text)				Sample	Number of Residuals Beyond Desired Limits (see text)			
	0	1	2	More than 2		0	1	2	More than 2
DH5-163.7	X		0		DH4-56.7	X	0		
DH5-171.0		0 X			DH4-66.8	X	0		
DH5-171.3	X	0			DH4-72.2	X	0		
DH5-173.1		X			DH4-75.3	X	0		
DH5-182.3	X				DH4-76.5	X	0		
DH5-183.2	X		0		DH4-81.7	X	0		
DH5-179.8	X				DH4-87.2	X	0		
DH5-183.5	X				DH4-93.3	X	0		
DB5-190.2		X			DH4-99.1	X		0	
DB5-192.9			X		DH4-103.3	X	0		
DB5-197.2	X				DC14-234.1				X
DB5-204.2	X				DC14-237.1		0		X
DB5-210.6	X				DC14-240.2	X		0	
DB5-222.8	X				DC14-243.5	X		0	
DC6-242.0		X			DC14-245.36			0 X	
DC6-246.6	X				DC14-245.39	X		0	
DC6-250.6	X				DC14-246.6	X		0	
DC6-257.6	X				DC14-249.6	X			0
DC6-261.5		X			DC14-255.4	X		0	
DC6-267.3	X				DC14-258.2	X		0	
DB2-210.3	X				DC14-260.1	X			0
DB2-213.1	X				DC14-264.2	X		0	
A1303 (Type	X				DC14-265.8		X	0	
A1304 (Locality	X				DC14-267.4	X		0	
DC14-294.1	X		0		DC14-281.6	X		0	
DC14-295.4	X				DC14-287.7	X		0	
					DC14-290.5	X	0		

X - Residuals for oxides
0 - Residuals for trace elements

TABLE C

Typical Olivine Compositions from the Huntzinger Flow, Pasco Basin

Oxide / Sample	SiO_2	Al_2O_3	FeO	MnO	CaO	MgO	K_2O
1	37.22	0.07	28.45	0.43	0.39	33.30	0.04
2	38.44	0.10	24.15	0.28	0.33	36.68	0.02
3	33.90	0.03	46.99	--	0.35	19.07	--
4	33.86	0.08	48.57	--	0.44	17.08	--
5	34.52	0.46	40.81	--	0.42	23.96	--
6	35.12	0.05	37.52	--	0.31	27.65	--
7	34.27	0.08	42.02	--	0.34	23.87	--
8	37.76	0.06	27.10	--	0.25	35.65	--
9	35.22	0.04	41.84	--	0.28	23.73	--
10	35.07	0.00	41.95	--	0.32	23.12	--

1. Groundmass, DC14-243.5
2. Groundmass, DC14-243.5
3. Groundmass, in glassy part, DC14-245.36
4. Groundmass, in glassy part, DC14.245.36
5. Groundmass, subophitic part, DC14-245.36
6. Groundmass core, subophitic part, DC14-245.36
7. Rim of 6
8. Phenocryst core, DC14-265.8
9. Rim of 8
10. Groundmass, DC14-265.8

Oxide / Sample	Na_2O	TiO_2	CR_2O_5	NiO	Total	FO%
1	0.03	0.11	--	--	100.04	67
2	0.01	0.00	--	--	100.01	73
3	--	0.07	0.00	0.04	100.45	42
4	--	0.12	0.03	0.05	100.23	39
5	--	0.08	0.01	0.46	100.72	51
6	--	0.04	0.00	0.06	100.75	57
7	--	0.09	0.00	0.05	100.72	50
8	--	0.03	0.00	0.06	100.91	70
9	--	0.02	0.00	0.03	101.16	50
10	--	0.03	0.00	0.05	100.54	50

1. Groundmass, DC14-243.5
2. Groundmass, DC14-243.5
3. Groundmass, in glassy part, DC14-245.36
4. Groundmass, in glassy part, DC14.245.36
5. Groundmass, subophitic part, DC14-245.36
6. Groundmass core, subophitic part, DC14-245.36
7. Rim of 6
8. Phenocryst core, DC14-265.8
9. Rim of 8
10. Groundmass, DC14-265.8

TABLE D

Typical Plagioclase Compositions from the Huntzinger Flow, Pasco Basin

Oxide / Sample	SiO_2	Al_2O_3	FeO	MnO	CaO	MgO	K_2O	Na_2O
1	54.03	27.87	0.62	0.00	11.98	0.18	0.44	4.51
2	55.45	26.89	0.70	0.02	10.55	0.12	0.60	5.24
3	53.27	28.74	0.70	0.11	12.55	0.12	0.40	4.04
4	51.88	29.64	0.55	0.00	13.61	0.24	0.28	3.83
5	52.41	29.10	0.64	0.00	12.89	0.21	0.57	4.10
6	51.64	30.15	0.63	0.02	13.67	0.20	0.22	3.65
7	54.60	28.32	0.71	0.04	11.81	0.22	0.36	4.45
8	51.59	30.00	0.60	0.00	13.93	0.21	0.24	3.34

1. Phenocryst core, DC14-234.1
2. Rim of 1
3. Phenocryst core, DC14-234.1
4. Rim of 3
5. Groundmass, DC14-234.1
6. Groundmass, DC14-243.5
7. Phenocryst core, DC14-243.5
8. Rim of 7

Oxide / Sample	TiO_2	Total	AB	OR	AN
1	0.12	99.75	39.5	2.5	58.0
2	0.15	99.72	45.7	3.5	50.8
3	0.05	99.98	36.0	2.3	61.7
4	0.08	100.11	33.2	1.6	65.2
5	0.09	100.01	35.4	3.2	61.4
6	0.00	100.18	32.1	1.3	66.6
7	0.06	100.57	39.7	2.1	58.2
8	0.07	99.98	29.9	1.4	68.7

1. Phenocryst core, DC14-234.1
2. Rim of 1
3. Phenocryst core, DC14-234.1
4. Rim of 3
5. Groundmass, DC14-234.1
6. Groundmass, DC14-243.5
7. Phenocryst core, DC14-243.5
8. Rim of 7

TABLE E

Typical Proxene Compositions from the Huntzinger Flow, Pasco Pasin

Oxide / Sample	SiO_2	Al_2O_3	FeO	MnO	CaO	MgO	K_2O	Na_2O
1	51.07	2.82	10.87	0.14	17.68	15.64	0.00	0.28
2	53.52	1.25	10.14	0.34	15.40	18.74	0.01	0.22
3	50.71	2.37	12.54	0.38	16.55	15.09	0.04	0.21
4	50.96	3.26	8.31	0.30	19.94	15.60	0.00	0.30
5	49.89	2.30	17.52	0.31	15.57	12.27	0.01	0.26
6	49.53	2.84	13.31	0.00	20.13	11.89	NA	NA
7	53.34	0.62	21.32	NA	4.18	20.79	NA	NA
8	50.69	1.93	17.66	NA	17.12	12.66	NA	NA
9	51.00	3.28	6.91	NA	19.96	17.05	NA	NA
10	49.85	2.03	12.31	NA	17.16	15.03	NA	NA
11	53.04	1.53	7.14	NA	18.49	18.55	NA	NA
12	50.31	1.38	15.56	NA	14.34	15.34	NA	NA
13	53.46	0.65	20.03	NA	3.76	21.63	NA	NA
14	50.82	1.76	15.68	NA	15.75	14.29	NA	NA

1. Augite DC14-234.1
2. Augite DC14-234.1
3. Augite DC14-243.5
4. Augite DC14-243.5
5. Augite enclosed by Plagioclose, DC14-243.5
6. Augite in glassy portion DC14-245.36
7. Pigeonite core, DC14-245.36 glassy portion
8. Augite rim for 7
9. Ophitic augite core, DC14-249.6
10. Rim for 9
11. Ophitic augite core, DC14-249.6
12. Rim for 11
13. Pigeonite core, DC14-267.3
14. Augite rim for 13

NA - Not Analyzed

Oxide / Sample	TiO_2	Cr_2O_3	Total	WO	EN	FS
1	1.10	NA	99.60	36.8	45.3	17.9
2	0.52	NA	99.94	31.0	52.5	16.5
3	1.16	NA	99.05	34.7	44.1	21.2
4	1.42	NA	100.09	41.3	44.8	13.90
5	1.60	NA	99.73	33.0	37.0	30.0
6	1.75	0.05	99.59	36.4	40.1	23.5
7	0.55	0.00	100.80	8.40	58.2	33.4
8	1.02	0.00	101.08	35.3	36.3	28.4
9	0.91	0.76	99.87	40.7	48.3	11.0
10	1.52	0.00	97.90	36.0	43.9	20.1
11	0.62	0.48	99.84	37.0	51.8	11.2
12	1.10	0.00	98.03	30.0	44.6	25.4
13	0.42	0.00	99.95	7.6	60.8	31.6
14	0.99	0.02	99.34	32.9	41.5	25.6

1. Augite DC14-234.1
2. Augite DC14-234.1
3. Augite DC14-243.5
4. Augite DC14-243.5
5. Augite enclosed by Plagioclose, DC14-243.5
6. Augite in glassy portion DC14-245.36
7. Pigeonite core, DC14-245.36 glassy portion
8. Augite rim for 7
9. Ophitic augite core, DC14-249.6
10. Rim for 9
11. Ophitic augite core, DC14-249.6
12. Rim for 11
13. Pigeonite core, DC14-267.3
14. Augite rim for 13

NA - Not Analyzed

TABLE F

Summary of Selected Fractionation Modeling Results

Sample	Percent of Sample	Olivine		Plagioclase	
		Sample (1)	Percent	Sample (2)	Percent
DC14-234.1	96.0	1	0.5	2	- 2.9
DC14-237.1	92.4	1	5.0	---	---
DC14-240.2	97.5	1	2.5	---	---
DC14-245.39	97.8	3	2.2	---	---
DH5-171.0	81.6	3	4.0	1	10.79
DH5-171.3	90.3	3	3.6	2	6.1
DB5-190.2	87.4	1	5.7	7	6.9
DB5-192.9	90.8	3	4.6	2	4.6

(1) Olivine Analysis from Table C

(2) Plagioclase Analysis from Table D

(3) Proxene Analysis from Table E

(4) Number of Residuals above two standard deviations

Sample	Pyroxene		Percent Asotin Composition	Residuals (4)
	Sample (3)	Percent		
DC14-234.1	1	6.6	32.5	None
DC14-237.1	3	2.6	51.9	None
DC14-240.2	---	---	67.2	None
DC14-245.39	6	0.05	54.8	One (K_2O)
DH5-171.0	4	3.63	35.0	None
DH5-171.3	---	---	60.0	None
DB5-190.2	---	---	55.1	None
DB5-192.9	---	---	28.3	None

(1) Olivine Analysis from Table C

(2) Plagioclase Analysis from Table D

(3) Proxene Analysis from Table E

(4) Number of Residuals above two standard deviations