APPENDIX 5

PARAMETERS WITH INFLUENCE ON SEISMIC VELOCITY

Baseline Conceptual Model

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Baseline Conceptual Model

1. Source - Christensen (1968)

TABLE 1

COMPRESSIONAL WAVE VELOCITIES IN BASALT
(km/sec)

SAMPLE	DENSITY (g/cc)	PRESSURE (kb)							
		0.1	0.5	1.0	2.0	4.0	6.0	8.0	10.0
Basalt 1	2.91	5.8	6.03	6.08	6.13	6.21	6.25	6.28	6.33
	2.91	5.9	6.05	6.11	6.15	6.23	6.28	6.32	6.37
	2.88	5.6	5.76	5.86	5.97	6.03	6.10	6.16	6.20
Mean	2.90	5.8	5.95	6.02	6.08	6.16	6.21	6.25	6.30
Basalt 2	2.92	5.8	6.00	6.03	6.06	6.11	6.16	6.20	6.25
	2.91	5.8	6.04	6.07	6.09	6.14	6.20	6.24	6.28
	2.91	5.9	6.08	6.14	6.19	6.22	6.27	6.36	6.35
Mean	2.91	5.8	6.04	6.08	6.11	6.16	6.21	6.27	6.29
Basalt 3	2.95	6.0	6.14	6.19	6.25	6.34	6.36	6.42	6.46
	2.92	5.9	6.09	6.16	6.21	6.27	6.34	6.36	6.39
	2.94	6.0	6.11	6.17	6.25	6.29	6.34	6.38	6.42
Mean	2.94	6.0	6.11	6.17	6.24	6.30	6.35	6.39	6.42

Baseline Concept

2. Source – Kern (1982)

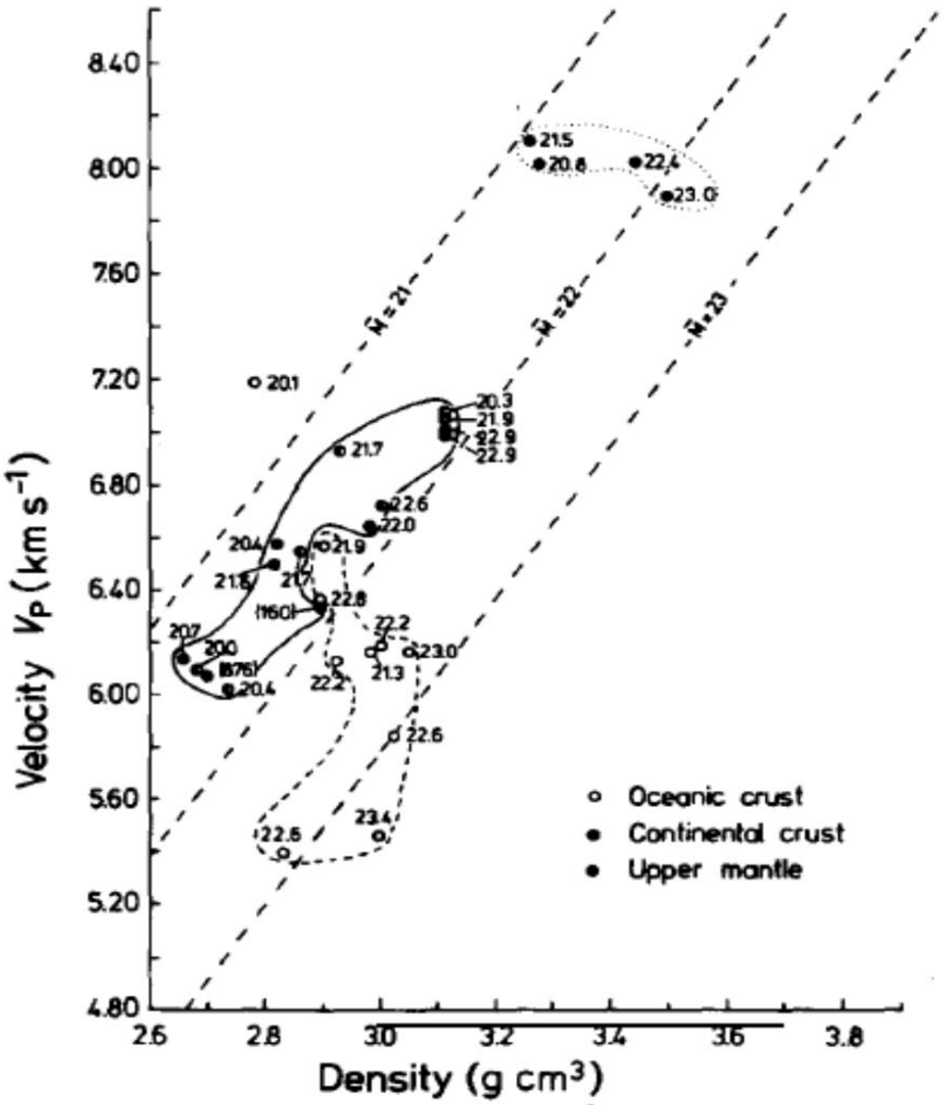

Fig. 2. Compressional-wave velocities v. density at 6 kbar confining pressure. The numbers attached to the symbols are mean atomic weights as calculated from the chemical analyses. Dashed lines represent lines of constant mean atomic weight, according to Birch (1961).

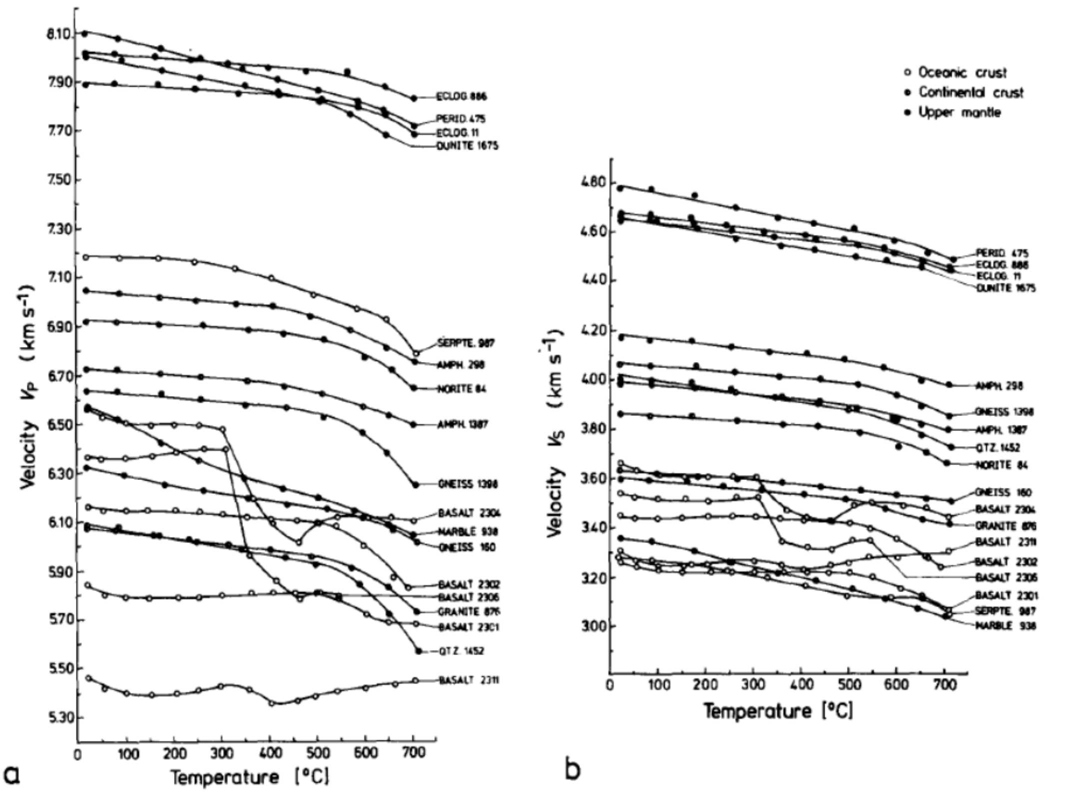

Fig. 5. Velocities of (a) compressional waves and (b) shear waves as a function of temperature at 6 kbar confining pressure for a series of selected rocks. V_P is the mean of the velocities measured in three orthogonal directions of the sample cubes. V_S is the velocity in one direction.

Baseline Con

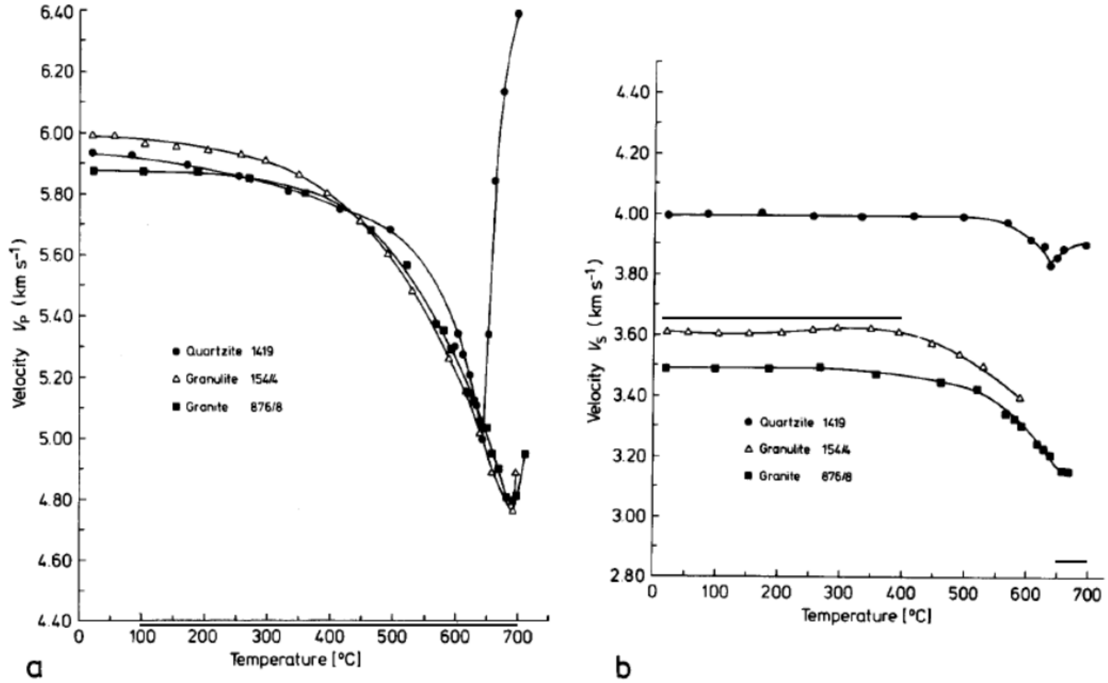

Fig. 7. Compressional-wave velocities (a) and shear wave velocities (b) as a function of temperature at 2 kbar confining pressure in quartzite, granite and granulite. The velocity curves are characterized by a kink which is associated with the $\alpha-\beta$ transition of quartz (from Kern, 1979).

Baseline Cons

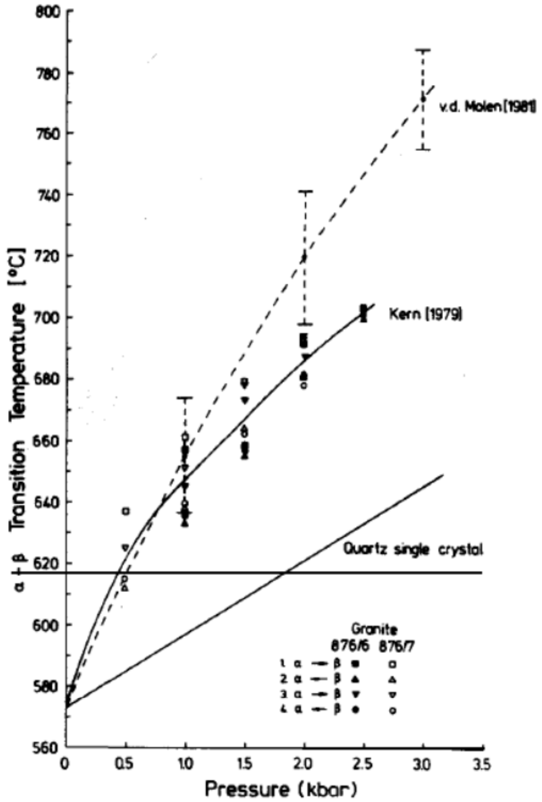

Fig. 8. The quartz $\alpha-\beta$ transition temperature in granite as a function of confining pressure, as obtained by V_P measurements. The dashed line presents results obtained by thermal expansion measurements on Delegate aplite (after van der Molen, 1981). The pressure dependence of $T_{\alpha-\beta}$ for quartz single crystals is also indicated.

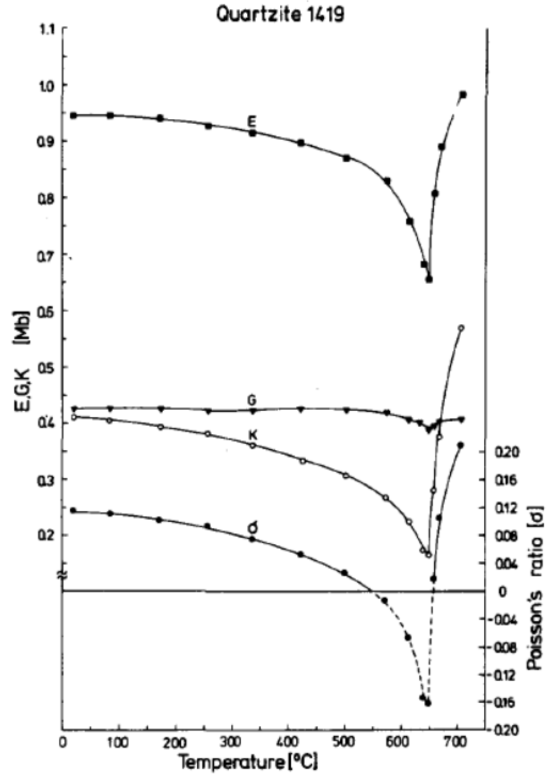

Fig. 9. Values of bulk modulus K, the shear modulus G, Young's modulus E, and the Poisson's ratio σ as a function of temperature at 2 kbar confining pressure for quartzite, calculated from the velocities according to the formulas for isotropic bodies (from Kern, 1979).

At the critical temperature V_P and V_S decrease irreversibly and further thermal cycling has no significant effect. This indicates that the irreversible dehydration breakdown reaction of zeolites contributes the major part for the decrease of wave velocities and not the fluid phase itself. To get more information about the causes for the velocity

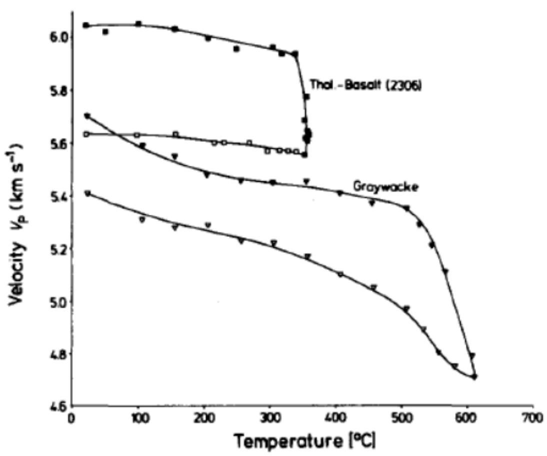

Fig. 10. Velocities of compressional waves for a jacketed sample of tholeiitic basalt (No. 2306) as a function of temperature at 6 kbar confining pressure (Kern and Richter, 1979) and for metagraywacke at 5 kbar confining pressure (Burkhardt et al., 1982). The solid symbols represent measurements on the way to higher temperature, the open symbols represent measurements on the way back to room temperature.

3. Source - Kern et al., (2001)

H. Kern et al. / Tectonophysics 338 (2001) 113–134 117

Table 1
Density at atmospheric pressure and 20°C (Abbreviations: alb: albite; amph: amphibole; ap: apatite; bio: biotite; ca: carbon; carb: carbonate; cem: cement; chl: chlorite; epi: epidote; grt: garnet; kf: kalifeldspar; ms: muscovite; plg: plagioclase; qz: quartz; ser: sericite; sph: sphene; sul: sulphide; tl:talc; zir: zircon; zoi: zoisite)

Sample	Rock type	Depth (m)	Modal composition	ρ (g cm^{-3})
Z1	Andesite–Metaporphyrite	4570[a]	20 qz; 30 bio; 10 amph; 40 ore; (epi)	2.95
17775S	Carbonatized schist	4673	3 chl; 35 carb; 38 tl; 18 ca; 5 alb; 1 sph	2.96
P5	Metam. Arkose	4880[a]	40 qz; 10 plg; 50 kf; (ser, cem)	2.64
18679	Mylonitized orthophyre	5056	43 qz; 55 alb; 2 bio; (carb, chl)	2.75
P2	Metadiabase	5150[a]	35 plg; 50 kf; 10 glass; 5 sph	2.99
M1	Andesite–Plagioporphyrite	5770[a]	20 plg; 35 bio; 50 chl; 5 ore; (qz, carb, zoi)	3.01
31115	Qtz–Fsp–Amphibolite	8718	10 qz; 30 plg; 60 amph; (ore, ap)	3.08
35400	Bio–Amphibolite	9438	32 bio; 64 amph; 4 ore, (ap, sph)	3.09
36058	Bio–Hbl–Gneiss	9571	31 bio; 65 amph; 4 ore, ap, sph	3.09
PP358	Bio–Plagiogneiss	9800[a]	32 qz; 43 plg; 23 bio; 2 grt, ms, ap, sph	2.72
38098S	Bio–Gneiss	10232	23 qz; 47 plg; 30 bio; (ore, sph)	2.72
PP363	Bio–Plagiogneiss	10700[a]	26 qz; 49 plg; 23 bio; 2 epi, ap, sul	2.77
PP365	Amphibolite	11100[a]	14 qz; 24 plg; 60 amph; 2 bio, ap, epi, sul	3.02
43560	Amphibolite	11384	60amph; 30 plg; 6 qz; 3 bio; 1 epi;	2.95
PP357	Amphibolite	11100[a]	13 qz; 20 plg; 65 amph; 2 epi, zir, sul	3.02
43726	Fsp–Amphibolite	11718	5 qz; 30 plg; 5 bio; 60 amph; (zoi)	2.94

[a] Correlation depth

Baseline Concep

Table 4
Compressional wave velocities (km s^{-1}) and velocity anisotropies (%) at various confining pressures (20°C) and temperatures (600 MPa)

Sample	Propagation direction	Pressure, MPa (20°C)						Temperature, °C (600 MPa)			
		25	50	100	200	400	600	100	200	400	600
Z1	*X*	6.39	6.47	6.53	6.61	6.68	6.73	6.72	6.69	6.61	6.55
	Y	6.35	6.41	6.47	6.54	6.62	6.66	6.65	6.62	6.54	6.48
	Z	6.39	6.44	6.51	6.59	6.67	6.71	6.69	6.67	6.60	6.54
	Mean	6.38	6.44	6.51	6.58	6.66	6.70	6.69	6.66	6.59	6.52
	Anis	0.67	0.95	0.95	1.05	1.04	1.04	1.09	1.01	1.05	1.04
17775S	*X*	5.30	5.64	5.86	6.02	6.14	6.20	6.17	6.12	6.10	6.08
	Y	4.93	5.32	5.57	5.74	5.88	5.97	5.93	5.86	5.83	5.78
	Z	4.06	4.62	5.01	5.26	5.44	5.58	5.56	5.51	5.47	5.41
	Mean	4.76	5.19	5.48	5.67	5.82	5.92	5.89	5.83	5.80	5.76
	Anis	26.07	19.55	15.47	13.43	12.03	10.46	10.33	10.52	10.81	11.62
P 5	*X*	6.55	6.56	6.58	6.62	6.66	6.69	6.67	6.62	6.51	6.32
	Y	6.46	6.48	6.51	6.53	6.60	6.64	6.61	6.57	6.45	6.24
	Z	6.70	6.71	6.76	6.81	6.85	6.88	6.86	6.82	6.73	6.55
	Mean	6.57	6.59	6.62	6.65	6.70	6.74	6.71	6.67	6.56	6.37
	Anis	3.62	3.51	3.75	4.12	3.79	3.62	3.68	3.85	4.36	4.87
18679S	*X*	5.29	5.66	5.93	6.18	6.29	6.32	6.31	6.27	6.20	6.11
	Y	5.28	5.69	6.01	6.23	6.31	6.33	6.30	6.27	6.20	6.07
	Z	4.56	5.14	5.73	6.17	6.34	6.40	6.36	6.33	6.25	6.12
	Mean	5.05	5.50	5.89	6.19	6.31	6.35	6.32	6.29	6.22	6.10
	Anis	14.46	10.15	4.75	1.00	0.89	1.20	0.96	1.02	0.87	0.77
P 2	*X*/c >	5.86	5.94	6.00	6.05	6.10	6.14	6.12	6.09	5.99	5.85
	Y	5.63	5.72	5.80	5.88	5.94	5.99	5.97	5.94	5.84	5.68
	Z	5.24	5.42	5.60	5.73	5.82	5.86	5.85	5.82	5.74	5.58
	Mean	5.58	5.69	5.80	5.88	5.95	5.99	5.98	5.95	5.86	5.71
	Anis	11.25	9.21	6.90	5.42	4.79	4.54	4.57	4.54	4.35	4.70
M1	*X*	6.60	6.65	6.69	6.73	6.78	6.82	6.79	6.73	6.61	6.40
	Y	6.55	6.60	6.65	6.70	6.75	6.79	6.76	6.70	6.58	6.36
	Z	6.56	6.60	6.66	6.73	6.79	6.83	6.79	6.73	6.62	6.39
	Mean	6.57	6.62	6.66	6.72	6.78	6.81	6.78	6.72	6.60	6.38
	Anis	0.67	0.76	0.57	0.48	0.53	0.54	0.44	0.49	0.61	0.56
31115	*X*	5.79	6.36	6.82	7.09	7.18	7.21	7.21	7.18	7.11	7.07
	Y	5.29	5.88	6.43	6.77	6.86	6.90	6.89	6.86	6.77	6.69
	Z	4.07	4.79	5.61	6.19	6.43	6.49	6.47	6.44	6.35	6.26
	Mean	5.05	5.68	6.29	6.68	6.82	6.86	6.86	6.83	6.75	6.67
	Anis	33.99	27.65	19.30	13.47	11.05	10.58	10.74	10.97	11.28	12.13
35400	*X*	4.64	5.10	5.43	5.69	5.87	5.99	5.96	5.91	5.82	5.76
	Y	5.42	5.82	6.21	6.56	6.77	6.86	6.84	6.82	6.78	6.78
	Z	5.49	6.07	6.67	7.16	7.42	7.50	7.49	7.49	7.50	7.52
	Mean	5.18	5.66	6.10	6.47	6.69	6.78	6.77	6.74	6.70	6.69
	Anis	16.38	17.17	20.42	22.84	23.08	22.26	22.63	23.33	25.08	26.33
36058	*X*	6.53	7.03	7.31	7.45	7.52	7.56	7.53	7.50	7.54	7.59
	Y	5.57	6.18	6.54	6.75	6.85	6.90	6.86	6.80	6.80	6.81
	Z	4.13	4.77	5.28	5.66	5.91	6.03	5.97	5.92	5.87	5.81
	Mean	5.41	6.00	6.37	6.62	6.76	6.83	6.79	6.74	6.74	6.74
	Anis	44.33	37.70	31.88	26.94	23.86	22.45	22.90	23.34	24.77	26.43

Table 4 (*continued*)

Sample	Propagation direction	Pressure, MPa (20°C)						Temperature, °C (600 MPa)			
		25	50	100	200	400	600	100	200	400	600
38098S	*X*	4.31	5.07	5.71	6.30	6.63	6.72	6.70	6.67	6.66	6.69
	Y	4.92	5.32	5.80	6.19	6.41	6.48	6.44	6.40	6.35	6.33
	Z	3.50	4.32	5.03	5.46	5.69	5.79	5.74	5.70	5.63	5.53
	Mean	4.24	4.90	5.51	5.98	6.24	6.33	6.29	6.26	6.21	6.18
	Anis	33.41	20.42	13.98	14.03	15.12	14.66	15.11	15.58	16.60	18.72
43560	*X*	5.29	5.96	6.48	6.83	6.96	7.00	6.99	6.96	6.92	6.86
	Y	5.11	5.69	6.29	6.69	6.84	6.88	6.85	6.84	6.80	6.69
	Z	3.86	4.98	5.85	6.56	6.83	6.88	6.87	6.86	6.82	6.74
	Mean	4.76	5.54	6.21	6.69	6.87	6.92	6.90	6.89	6.85	6.76
	Anis	30.13	17.72	10.12	4.02	1.88	1.71	2.03	1.71	1.81	2.57
43726	*X*	5.02	5.57	6.10	6.53	6.75	6.82	6.81	6.77	6.70	6.62
	Y	5.42	5.92	6.35	6.68	6.90	6.96	6.96	6.93	6.85	6.78
	Z	4.21	4.74	5.45	6.31	6.88	7.00	7.00	6.98	6.93	6.86
	Mean	4.88	5.41	5.97	6.51	6.84	6.93	6.92	6.90	6.83	6.75
	Anis	24.60	21.74	15.00	5.64	2.12	2.61	2.86	3.05	3.31	3.49
P 358	*X*	6.18	6.39	6.48	6.55	6.57	6.59	n.d.	n.d.	n.d.	n.d.
	Y	5.67	5.89	6.02	6.09	6.14	6.16	n.d.	n.d.	n.d.	n.d.
	Z	5.07	5.47	5.72	5.89	5.98	6.03	n.d.	n.d.	n.d.	n.d.
	Mean	5.64	5.92	6.07	6.18	6.23	6.26	n.d.	n.d.	n.d.	n.d.
	Anis	19.74	15.45	12.40	10.67	9.49	8.96	n.d.	n.d.	n.d.	n.d.
PP 363	*X*	6.14	6.35	6.42	6.50	6.56	6.58	6.55	6.54	6.50	6.43
	Y	5.88	6.09	6.22	6.28	6.32	6.36	6.32	6.28	6.23	6.12
	Z	5.15	5.40	5.58	5.70	5.79	5.85	5.81	5.79	5.69	5.58
	Mean	5.72	5.95	6.07	6.16	6.22	6.26	6.23	6.20	6.14	6.04
	Anis	17.17	16.04	13.80	13.07	12.41	11.58	11.82	12.13	13.19	13.92
PP 357	*X*	7.07	7.19	7.19	7.25	7.30	7.31	7.29	7.27	7.24	7.20
	Y	6.24	6.61	6.78	6.85	6.89	6.91	6.87	6.84	6.80	6.69
	Z	5.45	5.93	6.22	6.39	6.49	6.52	6.51	6.49	6.42	6.31
	Mean	6.25	6.58	6.73	6.83	6.89	6.91	6.89	6.86	6.82	6.74
	Anis	25.80	19.15	14.49	12.58	11.71	11.40	11.38	11.38	11.98	13.23
PP 365	*X*	6.84	6.94	7.00	7.02	7.05	7.08	7.05	7.03	6.97	6.88
	Y	6.96	7.06	7.10	7.13	7.14	7.14	7.12	7.10	7.06	6.95
	Z	5.89	6.06	6.15	6.23	6.28	6.33	6.30	6.27	6.19	6.07
	Mean	6.56	6.69	6.75	6.79	6.82	6.85	6.82	6.80	6.74	6.63
	Anis	16.33	14.99	14.04	13.22	12.49	11.81	12.06	12.24	12.78	13.27

Base

Table 5
Shear wave velocities and maximum shear wave splitting values (km s^{-1}) at various pressures (20°C) and temperatures (600 MPa)

Sample	Propagation direction	Pressure, MPa (20°C)						Temperature, °C (600 MPa)			
		25	50	100	200	400	600	100	200	400	600
Z1	*X*	3.70	3.75	3.81	3.84	3.86	3.87	3.87	3.85	3.80	3.75
	Y	3.74	3.79	3.81	3.83	3.84	3.85	3.85	3.84	3.79	3.74
	Z	3.71	3.75	3.79	3.83	3.85	3.86	3.86	3.85	3.80	3.75
	Mean	3.71	3.76	3.81	3.83	3.85	3.86	3.86	3.85	3.79	3.75
	ΔV_S//Fol.	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
17775S	*X*	3.15	3.33	3.44	3.52	3.58	3.61	3.58	3.54	3.53	3.50
	Y	2.97	3.18	3.30	3.39	3.46	3.50	3.47	3.43	3.41	3.37
	Z	2.77	2.93	3.03	3.13	3.19	3.23	3.20	3.16	3.15	3.12
	Mean	2.96	3.14	3.26	3.35	3.41	3.45	3.42	3.38	3.36	3.33
	ΔV_S//Fol.	0.06	0.05	0.02	0.02	0.01	0.00	0.00	0.01	0.01	0.01
P 5	*X*	3.54	3.63	3.66	3.70	3.72	3.72	3.73	3.73	3.69	3.67
	Y	3.53	3.60	3.65	3.69	3.71	3.71	3.72	3.71	3.68	3.64
	Z	3.38	3.49	3.59	3.67	3.70	3.71	3.72	3.72	3.69	3.63
	Mean	3.48	3.57	3.63	3.68	3.71	3.71	3.72	3.72	3.69	3.64
	ΔV_S//Fol.	0.05	0.00	0.01	0.01	0.02	0.01	0.01	0.02	0.00	0.02
18679S	*X*	3.07	3.30	3.46	3.58	3.63	3.64	3.62	3.60	3.58	3.53
	Y	3.01	3.23	3.44	3.56	3.61	3.62	3.60	3.58	3.55	3.50
	Z	2.98	3.16	3.37	3.52	3.57	3.59	3.57	3.55	3.53	3.47
	Mean	3.02	3.23	3.42	3.55	3.60	3.61	3.60	3.58	3.55	3.50
	ΔV_S//Fol.	0.18	0.15	0.07	0.08	0.11	0.11	0.11	0.11	0.12	0.10
P 2	*X*	3.71	3.75	3.78	3.79	3.79	3.80	3.79	3.75	3.66	3.53
	Y	3.68	3.73	3.75	3.75	3.76	3.77	3.75	3.71	3.63	3.49
	Z	3.71	3.74	3.77	3.79	3.81	3.81	3.80	3.77	3.69	3.55
	Mean	3.70	3.74	3.77	3.78	3.78	3.79	3.78	3.75	3.66	3.52
	ΔV_S//Fol.	0.06	0.16	0.11	0.08	0.07	0.07	0.08	0.08	0.09	0.10
M1	*X*	3.62	3.67	3.71	3.73	3.74	3.74	3.72	3.68	3.59	3.45
	Y	3.64	3.70	3.72	3.72	3.72	3.73	3.71	3.67	3.58	3.44
	Z	3.60	3.64	3.68	3.70	3.72	3.73	3.71	3.67	3.59	3.44
	Mean	3.62	3.67	3.70	3.71	3.73	3.74	3.71	3.67	3.59	3.44
	ΔV_S//Fol.	0.01	0.01	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01
31115	*X*	3.07	3.43	3.74	3.96	4.04	4.05	4.06	4.04	3.97	3.94
	Y	2.98	3.34	3.69	3.92	4.00	4.01	4.02	4.00	3.94	3.89
	Z	2.78	3.13	3.50	3.76	3.86	3.88	3.88	3.86	3.82	3.76
	Mean	2.94	3.30	3.64	3.88	3.96	3.98	3.99	3.97	3.91	3.86
	ΔV_S//Fol.	0.59	0.48	0.34	0.32	0.35	0.35	0.36	0.36	0.35	0.35
35400	*X*	2.69	2.83	3.00	3.16	3.26	3.31	3.28	3.23	3.15	3.14
	Y	2.95	3.17	3.40	3.60	3.70	3.74	3.72	3.69	3.62	3.59
	Z	2.69	2.96	3.28	3.55	3.71	3.76	3.74	3.71	3.65	3.62
	Mean	2.78	2.99	3.23	3.43	3.56	3.60	3.58	3.54	3.47	3.45
	ΔV_S//Fol.	0.89	0.95	1.05	1.08	1.05	1.03	1.05	1.08	1.08	1.07
36058	*X*	3.08	3.39	3.56	3.69	3.76	3.74	3.76	3.71	3.69	3.65
	Y	3.00	3.30	3.50	3.64	3.72	3.75	3.72	3.68	3.66	3.62
	Z	2.59	2.84	3.02	3.14	3.22	3.25	3.21	3.15	3.11	3.06
	Mean	2.89	3.17	3.36	3.49	3.57	3.58	3.56	3.51	3.49	3.44
	ΔV_S//Fol.	0.88	0.93	0.96	1.02	1.04	1.02	1.04	1.08	1.14	1.10

Table 5 (*continued*)

Sample	Propagation direction	Pressure, MPa (20°C)						Temperature, °C (600 MPa)			
		25	50	100	200	400	600	100	200	400	600
38098S	*X*	2.38	2.77	3.08	3.31	3.48	3.55	3.53	3.51	3.48	3.44
	Y	2.49	2.84	3.14	3.36	3.52	3.58	3.56	3.55	3.53	3.48
	Z	2.32	2.61	2.87	2.98	3.14	3.19	3.15	3.12	3.08	3.01
	Mean	2.40	2.74	3.03	3.22	3.38	3.44	3.41	3.39	3.36	3.31
	ΔV_S//Fol.	0.42	0.43	0.46	0.51	0.58	0.60	0.61	0.64	0.69	0.69
43560	*X*	2.96	3.82	3.91	3.96	4.00	4.02	4.01	3.98	3.91	3.87
	Y	2.76	3.85	3.90	3.95	3.99	4.00	3.99	3.96	3.90	3.84
	Z	2.63	3.75	3.80	3.84	3.88	3.89	3.88	3.85	3.79	3.75
	Mean	2.78	3.81	3.87	3.92	3.95	3.97	3.96	3.93	3.87	3.82
	ΔV_S//Fol.	0.38	0.27	0.07	0.01	0.00	0.01	0.02	0.02	0.02	0.03
43726	*X*	2.97	3.25	3.54	3.82	4.01	4.04	4.05	4.03	3.98	3.95
	Y	2.93	3.18	3.48	3.81	4.01	4.04	4.05	4.04	4.00	3.97
	Z	2.92	3.22	3.58	3.92	4.13	4.17	4.18	4.17	4.12	4.08
	Mean	2.94	3.22	3.53	3.85	4.05	4.08	4.09	4.08	4.03	4.00
	ΔV_S//Fol.	0.38	0.31	0.08	0.11	0.10	0.09	0.09	0.09	0.07	0.07
PP 358	*X*	3.36	3.50	3.59	3.63	3.64	3.64	n.d.	n.d.	n.d.	n.d.
	Y	3.23	3.42	3.53	3.58	3.60	3.61	n.d.	n.d.	n.d.	n.d.
	Z	3.16	3.32	3.41	3.49	3.52	3.53	n.d.	n.d.	n.d.	n.d.
	Mean	3.25	3.41	3.51	3.57	3.59	3.60	n.d.	n.d.	n.d.	n.d.
	ΔV_S//Fol.	0.20	0.17	0.15	0.17	0.18	0.17	n.d.	n.d.	n.d.	n.d.
PP 363	*X*	3.36	3.54	3.58	3.59	3.60	3.60	3.57	3.56	3.54	3.49
	Y	3.28	3.46	3.50	3.52	3.55	3.58	3.54	3.63	3.61	3.58
	Z	3.07	3.15	3.21	3.25	3.29	3.31	3.27	3.25	3.23	3.16
	Mean	3.24	3.38	3.43	3.46	3.48	3.50	3.46	3.48	3.46	3.41
	ΔV_S//Fol.	0.57	0.55	0.54	0.56	0.52	0.48	0.51	0.77	0.85	0.91
PP 357	*X*	3.76	3.88	3.94	4.02	4.03	4.03	4.02	4.00	3.98	3.93
	Y	3.63	3.78	3.91	3.99	4.01	4.01	4.00	3.98	3.96	3.92
	Z	3.58	3.73	3.83	3.89	3.92	3.92	3.91	3.90	3.89	3.82
	Mean	3.65	3.80	3.89	3.97	3.99	3.99	3.98	3.96	3.94	3.89
	ΔV_S//Fol.	0.30	0.24	0.23	0.27	0.27	0.27	0.27	0.28	0.29	0.28
PP 365	*X*	3.82	3.92	3.98	4.00	3.99	3.99	3.97	3.94	3.89	3.82
	Y	3.79	3.89	3.96	3.97	3.97	3.97	3.95	3.93	3.89	3.81
	Z	3.60	3.66	3.69	3.71	3.73	3.74	3.71	3.69	3.66	3.56
	Mean	3.74	3.83	3.88	3.89	3.90	3.90	3.88	3.85	3.81	3.73
	ΔV_S//Fol.	0.39	0.42	0.51	0.51	0.51	0.49	0.49	0.50	0.51	0.50

4. Source: Burke and Fountain (1990)

TABLE 3

Compressional wave velocity at various confining pressures for Ivrea–Verbano and Strona–Ceneri samples

Sample No.	Density (g/cm^3)		Wave velocity (km/s) pressure (MPa):								
	bulk	grain	50	100	200	300	400	500	600	800	1000
IV-1A	3.085	nd	6.05	6.45	6.74	6.87	6.95	7.00	7.04	7.10	7.13
IV-1B	3.047	nd	6.40	6.75	6.97	7.07	7.11	7.15	7.19	7.23	7.25
IV-1C	3.054	nd	6.60	6.75	6.94	7.01	7.06	7.10	7.12	7.15	7.16
Mean	3.062	nd	6.35	6.65	6.88	6.98	7.04	7.08	7.12	7.16	7.18
Anis.			8.7	4.5	3.3	2.9	2.3	2.1	2.1	1.8	1.7
IV-4A	3.254	nd	7.69	7.78	7.92	8.00	8.03	8.07	8.10	8.15	8.20
IV-4B	3.236	nd	8.12	8.23	8.36	8.44	8.47	8.52	8.54	8.59	8.63
IV-4C	3.262	nd	8.20	8.30	8.43	8.54	8.57	8.64	8.66	8.73	8.75
IV-4D	3.186	nd	7.79	7.95	8.12	8.24	8.28	8.33	8.36	8.43	8.47
IV-4E	3.239	nd	8.10	8.20	8.29	8.34	8.38	8.42	8.45	8.49	8.53
IV-6A	3.076	nd	6.30	6.59	6.88	7.01	7.08	7.13	7.17	7.24	7.26
IV-6B	3.066	nd	6.75	7.00	7.29	7.41	7.49	7.54	7.56	7.60	7.61
IV-6C	3.058	nd	6.62	6.93	7.17	7.28	7.33	7.38	7.42	7.47	7.50
Mean	3.067	nd	6.56	6.84	7.11	7.23	7.30	7.35	7.38	7.44	7.46
Anis.			6.9	6.0	5.8	5.5	5.6	5.6	5.3	4.8	4.7
IV-7A	3.139	nd	6.60	6.76	6.98	7.10	7.18	7.23	7.28	7.36	7.39
IV-7B	3.088	nd	7.03	7.08	7.17	7.23	7.27	7.31	7.34	7.39	7.41
IV-7C	3.096	nd	7.03	7.10	7.21	7.31	7.36	7.40	7.44	7.45	7.46
Mean	3.108	nd	6.89	6.98	7.12	7.21	7.27	7.31	7.35	7.40	7.42
Anis.			6.2	4.9	3.2	2.9	2.5	2.3	2.2	1.2	0.9
IV-8A	2.870	nd	6.15	6.45	6.72	6.85	6.92	6.96	6.99	7.04	7.06
IV-8B	2.727	nd	6.33	6.43	6.54	6.59	6.62	6.65	6.68	6.72	6.74
IV-8C	2.774	nd	5.92	6.22	6.46	6.55	6.61	6.65	6.68	6.74	6.76
Mean	2.790	nd	6.13	6.37	6.57	6.66	6.72	6.75	6.78	6.83	6.85
Anis			6.7	3.6	4.0	4.5	4.6	4.6	4.6	4.7	4.7
IV-9A	2.903	nd	5.97	6.13	6.37	6.55	6.71	6.82	6.90	6.98	7.04
IV-9B	2.970	nd	6.09	6.54	6.84	6.96	7.02	7.07	7.11	7.15	7.16
IV-A	2.953	nd	6.40	6.62	6.81	6.92	6.99	7.04	7.08	7.13	7.16
Mean	2.942		6.15	6.43	6.67	6.81	6.91	6.98	7.03	7.09	7.12
Anis.			7.0	7.6	7.0	6.0	4.5	3.6	3.0	2.4	1.7
IV-11A	2.906	nd	6.30	6.54	6.72	6.79	6.83	6.86	6.89	6.94	6.96
IV-11B	2.942	nd	6.50	6.70	6.84	6.91	6.95	6.98	7.00	7.02	7.04
IV-11C	2.899	nd	6.42	6.60	6.80	6.84	6.98	7.02	7.06	7.09	7.12
Mean	2.916		6.41	6.61	6.79	6.85	6.92	6.95	6.98	7.02	7.04
Anis.			3.1	2.4	1.8	1.8	2.2	2.3	2.4	2.1	2.3
IV-13A	2.728	nd	5.15	5.32	5.47	5.57	5.64	5.71	5.77	5.85	5.88
IV-13B	2.741	nd	6.50	6.59	6.69	6.74	6.78	6.83	6.86	6.91	6.93
IV-13C	2.753	nd	6.07	6.19	6.30	6.39	6.47	6.51	6.56	6.64	6.68
Mean	2.741		5.91	6.03	6.15	6.23	6.30	6.35	6.40	6.47	6.50
Anis.			22.9	21.0	19.8	18.8	18.1	17.6	17.0	16.4	16.2
IV-14A	3.045	nd	6.86	7.03	7.21	7.31	7.36	7.40	7.43	7.49	7.51
IV-14B	3.122	nd	7.20	7.30	7.41	7.48	7.53	7.58	7.60	7.64	7.65
IV-14C	3.064	nd	7.18	7.25	7.33	7.38	7.42	7.46	7.50	7.53	7.55
Mean	3.077		7.08	7.19	7.32	7.39	7.44	7.48	7.51	7.55	7.57
Anis.			4.8	3.8	2.7	2.3	2.3	2.4	2.3	2.0	1.8

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TABLE 3 (continued)

Sample No.	Density (g/cm^3)		Wave velocity pressure (MPa):								
	bulk	grain	50	100	200	300	400	500	600	800	1000
IV-15A	3.077	nd	6.83	6.93	7.04	7.11	7.16	7.20	7.24	7.27	7.28
IV-15B	3.082	nd	7.22	7.32	7.44	7.51	7.53	7.56	7.58	7.62	7.65
IV-15C	3.081	nd	7.05	7.20	7.35	7.46	7.50	7.52	7.54	7.56	7.57
Mean	3.080		7.03	7.15	7.28	7.36	7.40	7.43	7.45	7.48	7.50
Anis			5.5	5.5	5.5	5.4	5.0	4.8	4.6	4.7	4.9
IV-16A	3.060	nd	5.76	6.20	6.64	6.81	6.89	6.95	7.00	7.05	7.06
IV-16B	3.076	nd	nd	6.08	6.89	7.00	7.12	7.20	7.27	7.35	7.37
IV-16C	3.050	nd	nd	6.22	6.87	7.14	7.28	7.37	7.43	7.49	7.51
Mean	3.062			6.17	6.80	6.98	7.10	7.17	7.23	7.30	7.31
Anis.				2.3	3.7	4.7	5.5	5.9	5.9	6.0	6.2
IV-17A	2.906	nd	6.95	7.05	7.16	7.22	7.26	7.29	7.32	7.36	7.38
IV-17B	2.905	nd	6.93	7.07	7.18	7.23	7.27	7.30	7.32	7.36	7.38
IV-17C	2.920	nd	6.47	6.75	6.98	7.09	7.15	7.20	7.24	7.28	7.29
Mean	2.910		6.78	6.96	7.11	7.18	7.23	7.26	7.29	7.33	7.35
Anis.			7.1	4.6	2.8	1.9	1.7	1.4	1.1	1.1	1.2
IV-19A	3.241	nd	7.03	7.30	7.55	7.68	7.75	7.80	7.84	7.89	7.91
IV-19B	3.250	nd	6.85	7.18	7.39	7.50	7.58	7.64	7.67	7.73	7.77
IV-19C	3.208	nd	6.75	7.10	7.36	7.49	7.57	7.63	7.67	7.73	7.74
Mean	3.233		6.88	7.19	7.43	7.56	7.63	7.69	7.73	7.78	7.81
Anis.			4.1	2.8	2.6	2.5	2.4	2.2	2.2	2.1	2.2
IV-20A	3.049	nd	nd	6.90	7.20	7.33	7.42	7.48	7.52	7.57	7.58
IV-20B	3.025	nd	6.25	6.74	7.18	7.31	7.39	7.44	7.48	7.53	7.55
IV-20°C	3.067	nd	6.25	6.80	7.19	7.34	7.42	7.47	7.51	7.57	7.59
Mean	3.047			6.81	7.19	7.33	7.41	7.46	7.50	7.56	7.57
Anis.				2.3	0.3	0.4	0.4	0.5	0.5	0.5	0.5
IV-21A	2.727	nd	4.94	5.24	5.53	5.64	5.73	5.80	5.86	5.95	5.99
IV-21B	2.725	nd	5.78	6.01	6.22	6.32	6.39	6.45	6.52	6.55	6.59
IV-21C	2.722	nd	5.76	5.97	6.16	6.28	6.35	6.41	6.45	6.49	6.50
Mean	2.725		5.49	5.74	5.97	6.08	6.16	6.22	6.28	6.33	6.36
Anis.			15.3	13.4	11.6	11.2	10.7	10.5	10.5	9.5	9.4
IV-22A	2.751	nd	5.70	5.86	6.00	6.07	6.12	6.16	6.19	6.21	6.24
IV-22B	2.753	nd	6.45	6.53	6.64	6.72	6.79	6.83	6.86	6.91	6.93
IV-22C	2.753	nd	6.10	6.27	6.37	6.43	6.48	6.50	6.53	6.59	6.65
Mean	2.752		6.08	6.22	6.34	6.41	6.46	6.50	6.53	6.57	6.61
Anis.			12.3	10.8	10.1	10.1	10.4	10.3	10.3	10.6	10.4
IV-23A	2.953	nd	6.26	6.37	6.49	6.55	6.60	6.64	6.68	6.75	6.77
IV-23B	2.945	nd	6.52	6.60	6.73	6.81	6.86	6.91	6.95	7.02	7.05
IV-23C	2.964	nd	6.68	6.84	7.00	7.09	7.16	7.20	7.23	7.27	7.31
Mean	2.954		6.49	6.60	6.74	6.82	6.87	6.92	6.95	7.01	7.04
Anis.			6.5	7.1	7.6	7.9	8.1	8.1	7.9	7.4	7.7
IV-24A	2.977	nd	6.10	6.36	6.56	6.68	6.76	6.80	6.84	6.91	6.95
IV-24B	2.972	nd	6.77	7.11	7.53	7.70	7.80	7.86	7.91	7.97	8.00
IV-24C	3.043	nd	6.78	7.05	7.41	7.64	7.83	7.98	8.06	8.16	8.22
Mean	2.997		6.55	6.84	7.17	7.34	7.46	7.55	7.60	7.68	7.72
Anis.			10.4	11.0	13.5	13.9	14.3	15.6	16.0	16.3	16.4

TABLE 3 (continued)

Sample No.	Density (g/cm^3)		Wave velocity								
			pressure (MPa):								
	bulk	grain	50	100	200	300	400	500	600	800	1000
IV-25A	3.055	nd	6.57	6.87	7.13	7.24	7.31	7.38	7.44	7.50	7.52
IV-25B	3.132	nd	6.65	6.91	7.19	7.35	7.39	7.42	7.45	7.52	7.57
IV-25C	3.067	nd	6.28	6.67	6.95	7.13	7.20	7.25	7.30	7.37	7.38
Mean	3.085		6.50	6.82	7.09	7.24	7.30	7.35	7.40	7.46	7.49
Anis.			5.7	3.5	3.4	3.0	2.6	2.3	2.0	2.0	2.5
IV-26A	3.298	3.298	7.44	7.48	7.53	7.57	7.60	7.63	7.65		
IV-26B	3.234	3.235	7.29	7.38	7.45	7.49	7.53	7.55	7.57		
IV-26C	3.321	3.231	7.60	7.65	7.72	7.76	7.80	7.85	7.87		
IV-26D	3.297	3.297	7.58	7.64	7.70	7.74	7.77	7.81	7.83		
IV-27A	2.883	2.928	6.55	6.69	6.80	6.85	6.87	6.90	6.93		
IV-27B	2.908	2.960	6.35	6.54	6.67	6.72	6.76	6.79	6.81		
IV-27C	2.879	2.934	6.34	6.56	6.66	6.71	6.75	6.78	6.80		
Mean	2.890	2.941	6.41	6.60	6.71	6.76	6.79	6.82	6.85		
Anis.			3.3	2.3	2.1	2.1	1.8	1.8	1.9		
IV-28A	2.908	2.986	6.31	6.48	6.58	6.61	6.64	6.67	6.70		
IV-28B	3.060	3.108	6.20	6.52	6.74	6.82	6.87	6.90	6.92		
IV-28C	3.009	3.081	6.21	6.52	6.71	6.77	6.81	6.85	6.86		
Mean	2.992	3.058	6.24	6.51	6.68	6.73	6.77	6.81	6.83		
Anis.			1.8	0.6	2.4	3.1	3.4	3.4	3.2		
IV-29A	2.950	3.073	5.85	6.19	6.44	6.55	6.62	6.65	6.67		
IV-29B	2.926	2.990	6.23	6.50	6.72	6.85	6.90	6.94	6.96		
IV-29C	2.971	3.065	6.19	6.43	6.63	6.73	6.79	6.83	6.86		
Mean	2.949	3.046	6.09	6.37	6.60	6.71	6.77	6.81	6.83		
Anis.			6.2	4.9	4.2	4.5	4.1	4.3	4.3		
IV-30A	2.897	2.906	5.78	5.95	6.16	6.27	6.31	6.35	6.39		
IV-30B	2.865	2.921	6.31	6.42	6.53	6.58	6.62	6.64	6.66		
IV-30C	2.855	2.891	6.29	6.52	6.67	6.72	6.74	6.76	6.79		
Mean	2.872	2.906	6.13	6.30	6.45	6.52	6.56	6.58	6.61		
Anis.			8.7	9.1	7.9	6.9	6.6	6.2	6.0		
IV-31A	2.895	2.986	5.45	5.67	5.87	6.00	6.09	6.14	6.18		
IV-31B	2.937	2.995	6.25	6.43	6.62	6.73	6.80	6.84	6.87		
IV-31C	2.867	2.941	6.26	6.39	6.52	6.60	6.67	6.71	6.73		
Mean	2.900	2.974	5.99	6.16	6.34	6.44	6.52	6.56	6.59		
Anis.			13.5	12.3	11.8	11.3	10.9	10.7	10.5		
IV-32A	2.735	2.828	5.17	5.80	6.12	6.25	6.31	6.35	6.36		
IV-32B	2.743	2.828	5.78	6.29	6.55	6.67	6.72	6.74	6.75		
IV-32C	2.737	2.831	nd	6.30	6.53	6.59	6.63	6.64	6.65		
Mean	2.738	2.829	nd	6.13	6.40	6.50	6.55	6.58	6.59		
Anis.				8.2	6.7	6.5	6.3	5.9	5.9		
IV-33A	2.615	2.703	5.14	5.55	5.84	6.00	6.09	6.15	6.20		
IV-33B	2.618	2.689	5.28	5.70	5.96	6.11	6.18	6.22	6.25		
IV-33C	2.628	2.709	5.48	5.80	6.06	6.16	6.22	6.26	6.30		
Mean	2.620	2.700	5.30	5.68	5.95	6.09	6.16	6.21	6.25		
Anis.			6.4	4.4	3.7	2.6	2.1	1.8	1.6		

TABLE 3 (continued)

Sample No.	Density (g/cm^3)		Wave velocity pressure (MPa):								
	bulk	grain	50	100	200	300	400	500	600	800	1000
IV-35A	2.731	2.785	5.64	6.82	6.92	5.95	5.99	6.02	6.04		
IV-35B	2.742	2.821	6.42	6.56	6.64	6.67	6.70	6.73	6.75		
IV-35C	2.737	2.794	5.91	6.04	6.12	6.15	6.19	6.23	6.25		
Mean	2.737	2.800	5.99	6.47	6.56	6.26	6.29	6.33	6.35		
Anis.			13.0	12.0	12.2	11.5	11.3	11.2	11.2		
IV-37A	2.671	2.744	5.09	5.51	5.77	5.87	5.92	5.96	5.98		
IV-37B	2.673	2.747	5.75	6.00	6.23	6.31	6.35	6.37	6.39		
IV-37C	2.692	2.749	5.30	5.70	5.99	6.09	6.15	6.18	6.20		
Mean	2.679	2.747	5.38	5.74	6.00	6.09	6.14	6.17	6.19		
Anis.			12.3	8.5	7.7	7.2	7.0	6.6	6.6		
IV-38A	2.724	2.789	4.95	5.31	5.55	5.67	5.74	5.79	5.81		
IV-38B	2.740	2.805	5.50	5.93	6.23	6.38	6.46	6.50	6.52		
IV-38C	2.719	2.801	5.63	5.96	6.24	6.36	6.42	6.46	6.49		
Mean	2.728	2.798	5.36	5.73	6.01	6.14	6.21	6.25	6.27		
Anis.			12.7	11.3	11.5	11.6	11.6	11.4	11.3		
IV-39A	2.744	2.839	5.10	5.37	5.69	5.89	5.97	6.03	6.07		
IV-39B	2.760	2.838	5.20	5.65	5.99	6.20	6.32	6.39	6.43		
IV-39C	2.795	2.840	5.74	6.00	6.28	6.40	6.46	6.51	6.54		
Mean	2.766	2.839	5.35	5.67	5.99	6.16	6.25	6.31	6.35		
Anis.			12.0	11.1	9.9	8.3	7.8	7.6	7.4		
IV-40A	3.320		8.04	8.19	8.30	8.32	8.35	8.38	8.41		
IV-40B	3.309		7.73	7.99	8.10	8.15	8.19	8.21	8.23		
IV-40D	3.309		8.14	8.22	8.44	8.50	8.52	8.54	8.56		
IV-41A	2.651	2.726	5.35	5.75	5.93	6.00	6.04	6.07	6.09		
IV-41B	2.652	2.732	5.40	5.90	6.24	6.33	6.38	6.42	6.44		
IV-41C	2.652	2.728	5.20	5.90	6.14	6.25	6.30	6.33	6.35		
Mean	2.652	2.729	5.32	5.85	6.10	6.19	6.24	6.27	6.29		
Anis.			3.8	2.6	5.1	5.3	5.4	5.6	5.6		
IV-42A	2.633	2.667	5.05	5.61	5.98	6.11	6.19	6.24	6.26		
IV-42B	2.642	2.689	5.19	5.65	6.00	6.13	6.18	6.22	6.25		
IV-42C	2.559	2.613	5.41	5.81	6.12	6.22	6.27	6.31	6.34		
MEAN	2.611	2.656	5.22	5.69	6.03	6.15	6.21	6.26	6.28		
Anis.			6.9	3.5	2.3	1.8	1.4	1.4	1.4		
IV-43A	2.688	2.758	5.11	5.35	5.59	5.70	5.77	5.81	5.85		
IV-43B	2.730	2.765	5.74	5.91	5.98	6.02	6.05	6.07	6.10		
IV-43C	2.717	2.767	5.34	5.66	5.93	6.06	6.12	6.17	6.21		
Mean	2.712	2.763	5.40	5.64	5.83	5.93	5.98	6.02	6.05		
Anis.			11.7	9.9	6.7	6.1	5.9	6.0	5.9		
IV-44A	2.589	2.634	6.25	6.35	6.41	6.44	6.48	6.50	6.52		
IV-44B	2.604	2.636	5.81	6.05	6.20	6.28	6.33	6.36	6.37		
IV-44C	2.600	2.650	5.80	6.02	6.15	6.23	6.27	6.30	6.34		
Mean	2.598	2.640	5.95	6.14	6.25	6.32	6.36	6.39	6.41		
Anis.			7.6	5.4	4.2	3.3	3.3	3.1	2.8		

TABLE 3 (continued)

Sample No.	Density (g/cm^3)		Wave velocity pressure (MPa):								
	bulk	grain	50	100	200	300	400	500	600	800	1000
IV-45A	2.934	2.981	5.65	6.08	6.46	6.61	6.68	6.71	6.74		
IV-45B	3.004	3.071	5.86	6.28	6.70	6.87	6.97	7.03	7.06		
IV-45C	2.916	2.992	5.88	6.27	6.68	6.85	6.94	7.00	7.04		
Mean	2.951	3.015	5.80	6.21	6.61	6.78	6.86	6.91	6.95		
Anis.			4.0	3.2	3.6	3.8	4.2	4.6	4.6		
IV-46A	3.254	3.342	7.87	7.93	7.96	7.98	8.00	8.03	8.05		
IV-46B	3.278	3.354	8.15	8.19	8.22	8.24	8.26	8.28	8.30		
IV-46C	3.295	3.366	7.73	7.78	7.84	7.86	7.89	7.93	7.95		
Mean	3.276	3.354	7.92	7.97	8.01	8.03	8.05	8.08	8.10		
Anis.			5.3	5.1	4.7	4.7	4.6	4.3	4.3		
IV-47A	2.771	2.840	5.73	6.02	6.30	6.41	6.47	6.51	6.53		
IV-47B	2.772	2.851	5.88	6.14	6.35	6.44	6.49	6.52	6.53		
IV-47C	2.781	2.855	5.88	6.17	6.38	6.46	6.51	6.55	6.57		
Mean	2.775	2.849	5.83	6.11	6.34	6.44	6.49	6.53	6.54		
Anis.			2.6	2.5	1.3	0.8	0.6	0.6	0.6		
IV-48A	3.231	3.272	6.67	6.80	6.92	6.95	6.99	7.02	7.04		
IV-48B	3.298	3.368	6.83	6.93	7.02	7.06	7.09	7.12	7.14		
IV-48C	3.266	3.325	6.85	6.98	7.09	7.13	7.15	7.17	7.19		
Mean	3.265	3.322	6.78	6.90	7.01	7.05	7.08	7.10	7.12		
Anis.			2.7	2.6	2.4	2.6	2.3	2.1	2.1		
IV-49A	3.027	3.085	6.25	6.85	7.14	7.25	7.29	7.33	7.35		
IV-49B	2.989	3.064	6.25	6.82	7.01	7.08	7.12	7.15	7.17		
IV-49C	2.989	3.045	6.28	6.82	7.05	7.13	7.17	7.19	7.21		
Mean	3.002	3.065	6.26	6.83	7.07	7.15	7.19	7.22	7.24		
Anis.			0.5	0.4	1.8	2.4	2.4	2.5	2.5		
IV-50A	3.028	3.106	5.95	6.24	6.41	6.48	6.51	6.54	6.56		
IV-50B	3.031	3.084	6.79	6.93	7.05	7.13	7.14	7.16	7.17		
IV-50C	3.049	3.124	6.46	6.69	6.90	6.99	7.05	7.08	7.11		
Mean	3.036	3.105	6.40	6.62	6.79	6.87	6.90	6.93	6.95		
Anis.			13.1	10.4	9.4	9.5	9.1	9.0	8.8		
IV-51A	2.993	3.013	5.77	6.01	6.22	6.32	6.39	6.44	6.47		
IV-51B	2.938	3.010	5.75	6.10	6.42	6.57	6.64	6.66	6.68		
IV-51C	2.790	2.871	5.67	5.96	6.19	6.30	6.35	6.40	6.43		
Mean	2.907	2.965	5.73	6.02	6.28	6.40	6.46	6.50	6.53		
Anis.			1.7	2.3	3.7	4.2	4.5	4.0	3.8		
IV-52A	2.654	2.700	5.78	5.97	6.12	6.18	6.23	6.27	6.30		
IV-52B	2.716	2.737	6.09	6.30	6.47	6.54	6.59	6.63	6.65		
IV-52C	2.679	2.716	6.32	6.44	6.55	6.62	6.67	6.69	6.71		
Mean	2.683	2.718	6.06	6.24	6.38	6.45	6.50	6.53	6.55		
Anis.			8.9	7.5	6.7	6.8	6.8	6.4	6.3		
IV-53A	2.656	2.692	5.21	5.53	5.72	5.80	5.84	5.87	5.89		
IV-53B	2.685	2.728	5.98	6.12	6.25	6.32	6.38	6.42	6.45		
IV-53C	2.673	2.694	5.82	5.97	6.11	6.17	6.21	6.25	6.28		
Mean	2.671	2.705	5.67	5.87	6.03	6.10	6.14	6.18	6.21		
Anis.			13.6	10.0	8.8	8.5	8.8	8.9	9.0		

TABLE 3 (continued)

Sample No.	Density (g/cm^3)		Wave velocity								
			pressure (MPa):								
	bulk	grain	50	100	200	300	400	500	600	800	1000
IV-54A	2.632	2.661	5.62	5.78	5.92	6.01	6.07	6.10	6.12		
IV-54B	2.648	2.664	6.03	6.06	6.10	6.14	6.18	6.20	6.23		
IV-54C	2.641	2.659	5.82	5.89	5.95	5.99	6.02	6.04	6.06		
Mean	2.640	2.661	5.82	5.91	5.99	6.05	6.09	6.11	6.14		
Anis.			7.0	4.7	3.0	3.6	2.9	2.5	2.5		
IV-55A	2.646	2.693	5.20	5.47	5.69	5.82	5.89	5.94	5.97		
IV-55B	2.656	2.698	5.29	5.62	5.88	6.01	6.09	6.14	6.18		
IV-55C	2.640	2.694	5.25	5.60	5.84	5.97	6.05	6.10	6.14		
Mean	2.647	2.695	5.25	5.56	5.80	5.93	6.01	6.06	6.10		
Anis.			1.7	2.7	3.3	3.2	3.3	3.3	3.4		

Baseline Conceptual

5. **Source: Brocher (2008)**

SEISMIC PROPERTIES OF ROCKS FROM THE IVREA ZONE

TABLE 4

Velocity, density and reflection coefficient model

Depth (km)	Lithology	Velocity (km/s)	Density (g/cm^3)	Reflection coefficient
0.0	dolomite	6.09	2.64	0.000
2.4	orthogneiss	5.82	2.64	0.023
6.3	paragneiss	5.88	2.70	0.016
7.2	orthogneiss	5.82	2.64	0.016
8.5	paragneiss	5.88	2.70	0.016
15.0	orthogneiss	5.82	2.64	0.016
15.6	paragneiss	5.88	2.70	0.016
17.0	granite	6.40	2.59	0.022
19.1	paragneiss	5.88	2.70	0.022
20.0	kinzigite	6.13	2.78	0.035
20.2	marble	6.36	2.74	0.011
20.3	kinzigite	6.13	2.78	0.011
21.0	marble	6.36	2.74	0.011
21.1	kinzigite	6.13	2.78	0.011
21.7	amphibolite	7.02	3.01	0.107
22.1	kinzigite	6.13	2.78	0.107
22.8	amphibolite	7.05	3.01	0.109
23.8	kinzigite	6.13	2.78	0.109
23.9	amphibolite	7.05	3.01	0.109
24.0	kinzigite	6.13	2.78	0.109
24.3	stronalite	6.87	3.00	0.095
24.6	mafic granofels	7.05	3.01	0.015
24.7	stronalite	6.87	3.00	0.015
24.8	mafic granofels	7.05	3.01	0.015
25.0	stronalite	6.87	3.00	0.015
26.0	mafic granofels	7.05	3.01	0.015
26.4	stronalite	6.87	3.00	0.015
27.1	pyriclasite	7.46	3.06	0.051
27.2	stronalite	6.87	3.00	0.051
27.4	pyriclasite	7.46	3.06	0.051
27.6	peridotite	8.06	3.25	0.069
28.0	pyriclasite	7.46	3.06	0.069
29.0	peridotite	8.06	3.25	0.069

eptual Model
Ba

" Initial tests of the model indicate that the Vp model generally compares favorably to regional seismic tomography models, but locally, the velocities assigned to a couple of units were in error: the Vp used for sedimentary rocks filling the La Honda Basin was too low, as was the Vp used for the Great Valley Sequence. Although they do not adversely affect the waveform fits, forward forward modeling suggests that the Vp and Vs model may be about 5% too fast on average (D. Dreger, personal comm., 2007; Rodgers et al., 2008). Because the velocity errors are largely restricted to the Franciscan Complex, within which the great majority of the modeled raypaths are located, they suggest that the relations proposed for the Franciscan Complex overpredict Vp by about 5%."

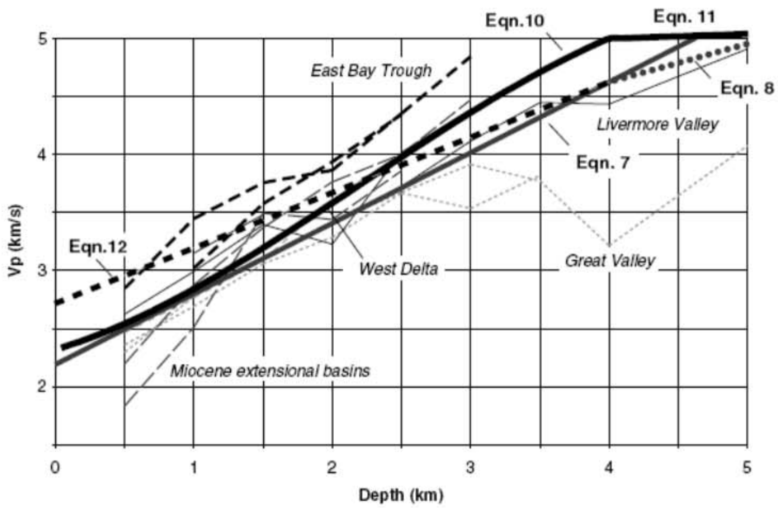


Figure 5. Average velocities within sedimentary basins in the greater San Francisco Bay Area, calculated by averaging the velocities predicted by linear regression of the sonic well logs at 0.5-km intervals (Brocher, 2005c). Averages calculated from the regressions of the upper and lower parts of the logs are shown with identical pattern to emphasize that they yield similar results. Heavy solid line shows the linear regression made directly to a subset of these well log data.

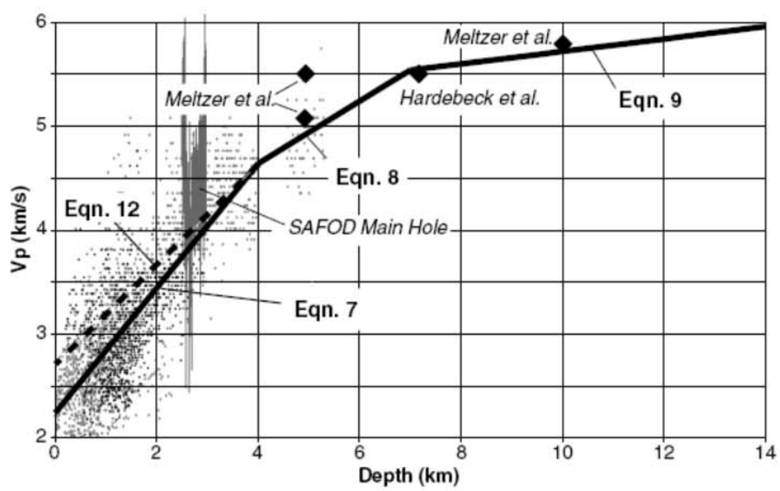


Figure 6. Linear regression (equation 6) of sonic velocity logs from 50 boreholes including 26 in the Great Valley and Sacramento delta, 15 in the Livermore Valley, and 9 in the East Bay trough (from Brocher, 2005c). Gray lines show sonic log from the SAFOD main hole, phase 2 sampling sedimentary rocks (Hickman *et al.*, 2005). Equations (8) and (9) are fit to seismic refraction/tomography velocities reported by Meltzer *et al.* (1987) and Hardebeck *et al.* (2007). Gray dots show sonic log values for Cenozoic sedimentary rocks; black dots show sonic log values for Great Valley sequence rocks (both from Brocher (2005c)).

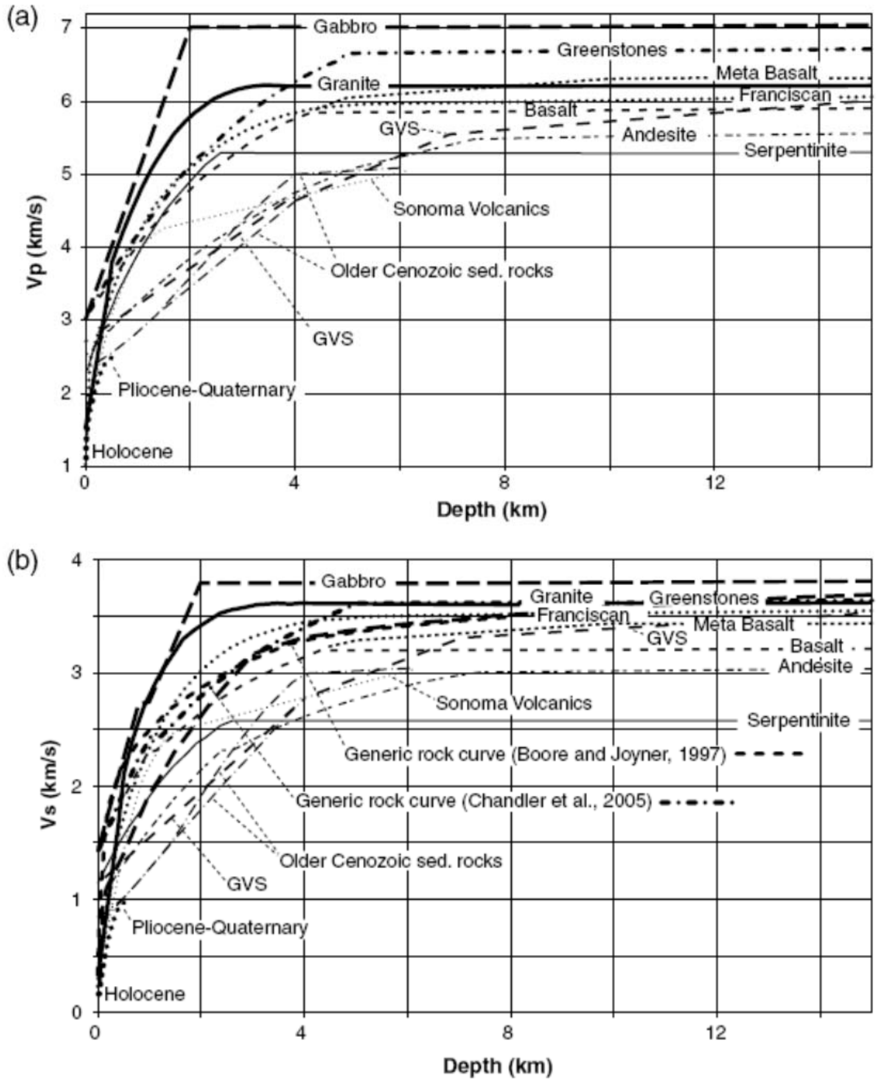


Figure 10. (a) Summary of the Vp versus depth relations for several rock types. (b) Summary of the Vs versus depth for the same rock types. Note that at higher velocities, the relative order of the curves differ from those in Figure 10a due to variations in the conversion from Vp to Vs with rock type (Table 3). Generic Vs versus depth curves proposed by Boore and Joyner (1997) and Chandler *et al.* (2005) are shown for comparison.

Bas

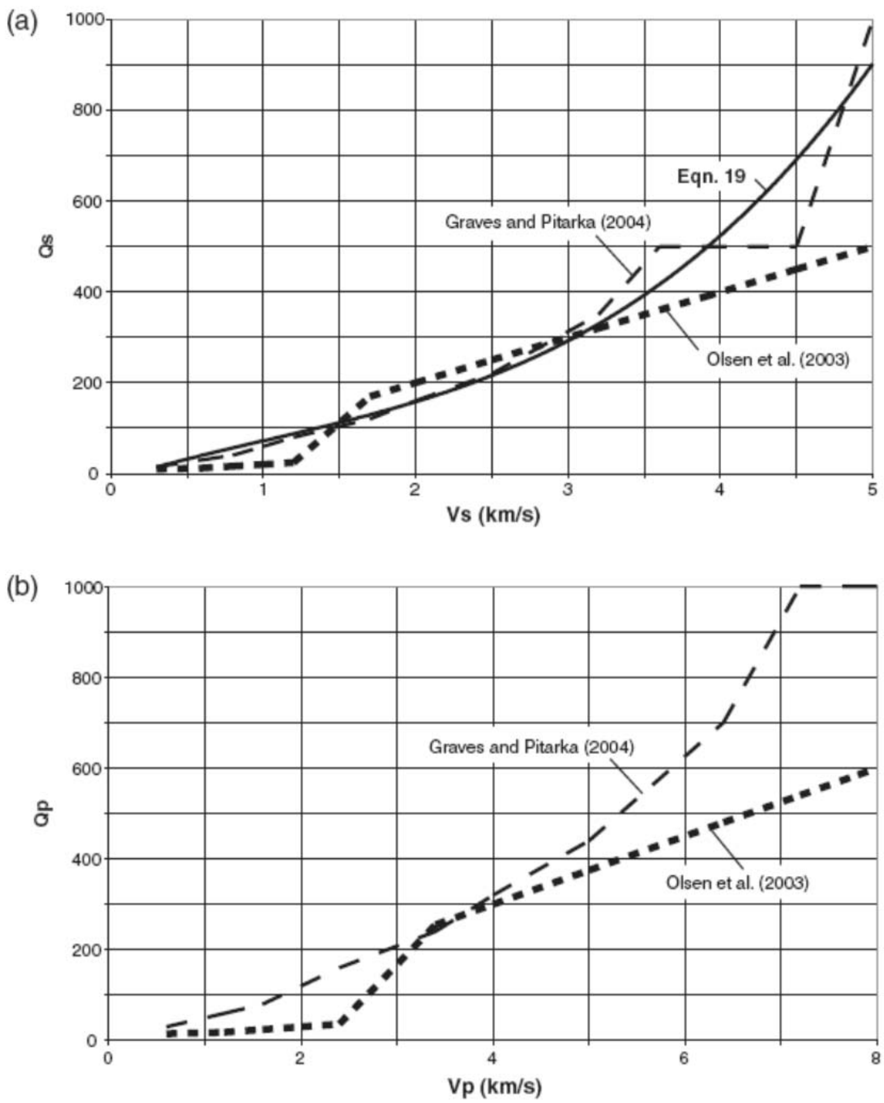


Figure 9. Comparison of attenuation versus velocity relations published by Olsen *et al.* (2003) and Graves and Pitarka (2004) for (a) Qs and Vs and (b) Qp and Vp.

Base

Table 4

Summary of Vs and Vp versus Depth Relationships

Relation	Depth Range	Rock Type
$Vp = 0.7 + 42.968z - 575.8z^2 + 2931.6z^3 - 3977.6z^4$	($z < 0.04$ km)	Plio-Quaternary deposits
$Vs = 0.215 + 10.932z - 138.1z^2$	($z < 0.04$ km)	Plio-Quaternary deposits
$Vp = 1.5 + 3.735z - 3.543z^2$	(0.04–0.5 km)	Plio-Quaternary deposits
$Vp = 0.7 + 31.4z$	($z < 0.05$ km)	Tertiary sed. rocks
$Vs = 0.2149 + 18.3z - 138.1z^2$	($z < 0.04$ km)	Tertiary sed. rocks
$Vp = 2.24 + 0.6z$	(0–4 km)	Tertiary sed. rocks
$Vp = 4.64 + 0.3(z - 4)$	(4–7 km)	Tertiary sed. rocks
$Vp = 5.54 + 0.06(z - 7)$	(> 7 km)	Tertiary sed. rocks
$Vp = 2.314 + 0.35z + 0.2z^2 - 0.03z^3$	(0.04–0.5 km)	Miocene basin fill
$Vp = 4.99 + 0.04(z - 4)$	(4–7 km)	Miocene basin fill
$Vp = 2.75 + 0.4725z$	(0.05–4 km)	Great Valley sequence
$Vp = 0.7 + 36z$	($z < 0.05$ km)	Franciscan Complex
$Vp = 2.5 + 1.963z - 0.424z^2 + 0.043z^3 - 0.002z^4 + 0.0000335z^5$	(0.05–9 km)	Franciscan Complex
$Vp = 6.0 + 0.01(z - 9)$	($z > 9$ km)	Franciscan Complex
$Vp = 1.5 + 4.41z$	($z < 0.05$ km)	Granitic rocks
$Vp = 2.5 + 2.9299z - 0.824z^2 + 0.1019z^3 - 0.0061z^4 + 0.0002z^5$	(0.05–4 km)	Granitic rocks
$Vp = 6.20 + 0.002(z - 4)$	($z > 4$ km)	Granitic rocks
$Qs = -16 + 104.13Vs - 25.225Vs^2 + 8.2184Vs^3$		($Vs > 0.3$ km/sec)
$Qs = 13$ for $Vs < 0.3$ km/sec		
$Qp = 2Qs$		

Vp and Vs in km/sec; depth, z, in kilometers.

Baseline Concepts

6. **Source: Krishna (1988)**

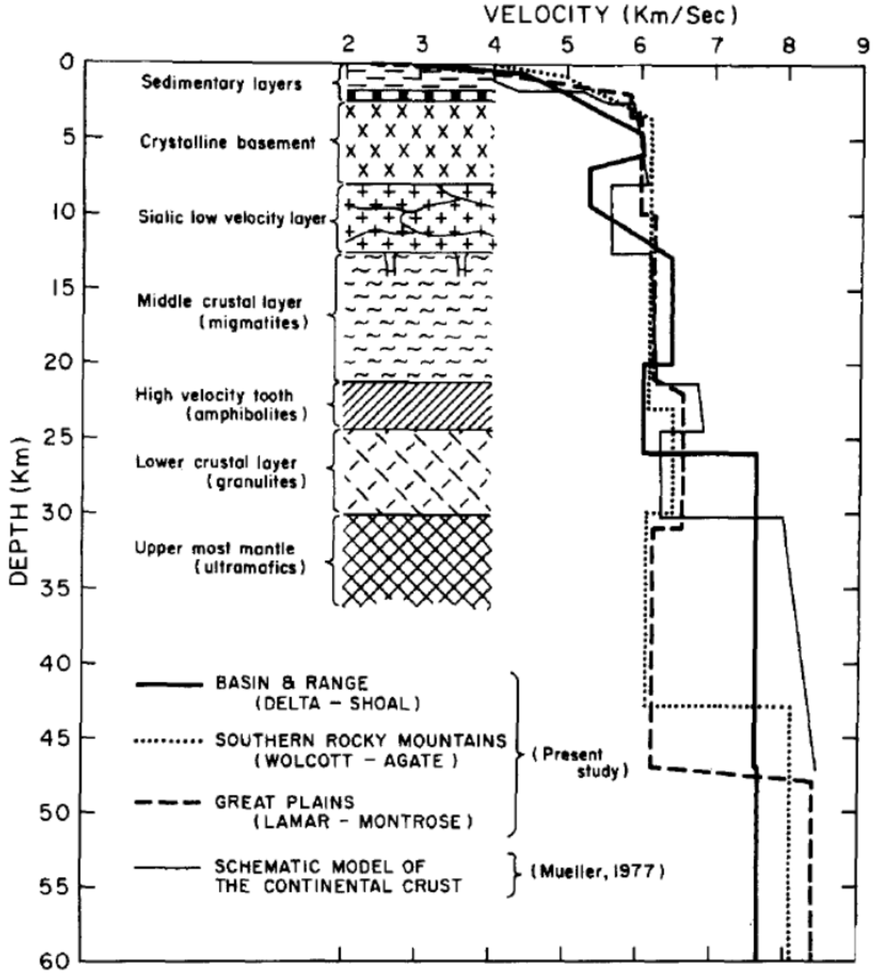
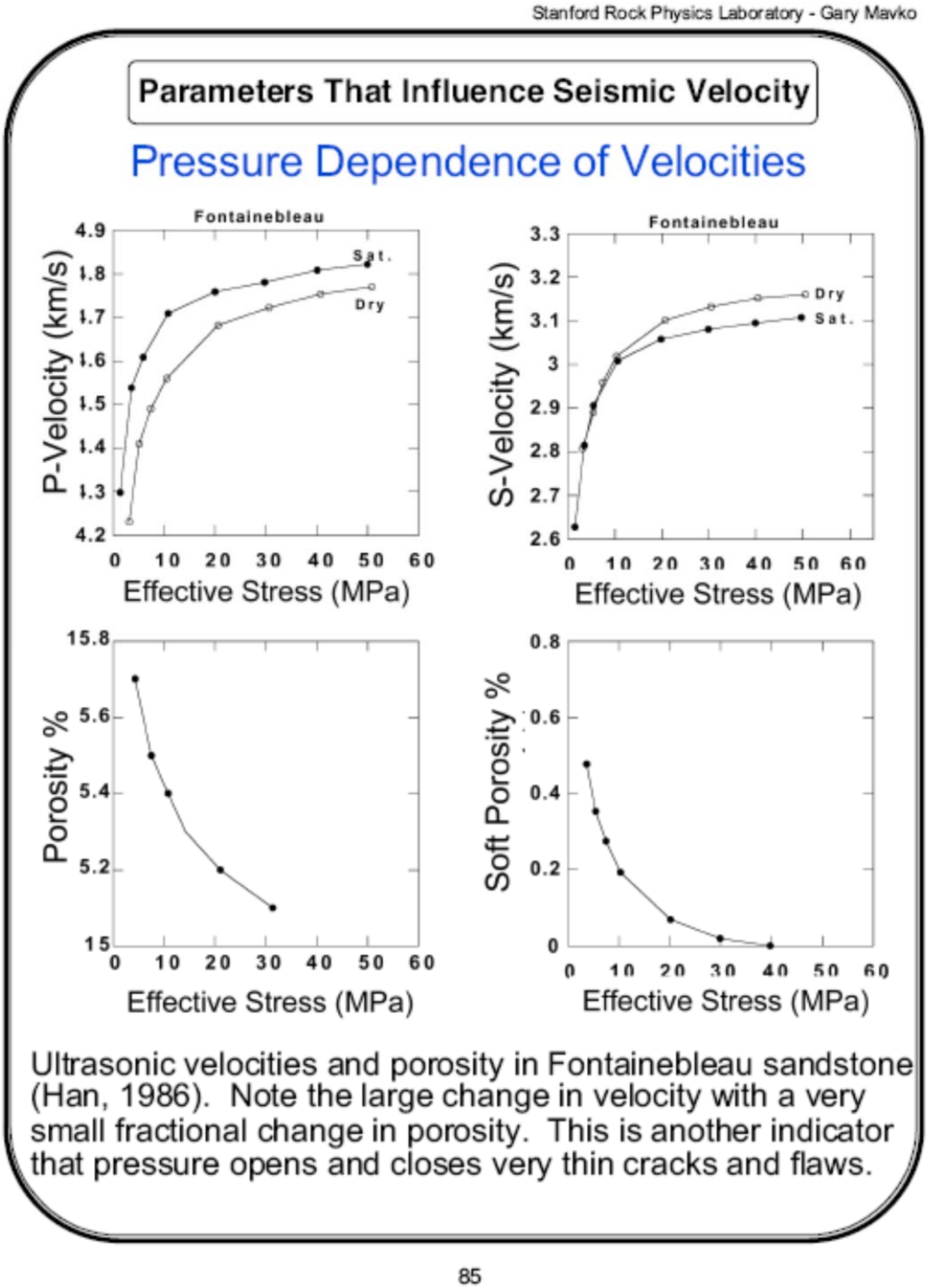


FIG. 15. Crustal *P* velocity-depth models for the Basin and Range, Southern Rocky Mountains and the Great Plains provinces in the Western United States obtained in the present study, along with the schematic model (shown for comparison) of the continental crust proposed by Mueller (1977).

Basel

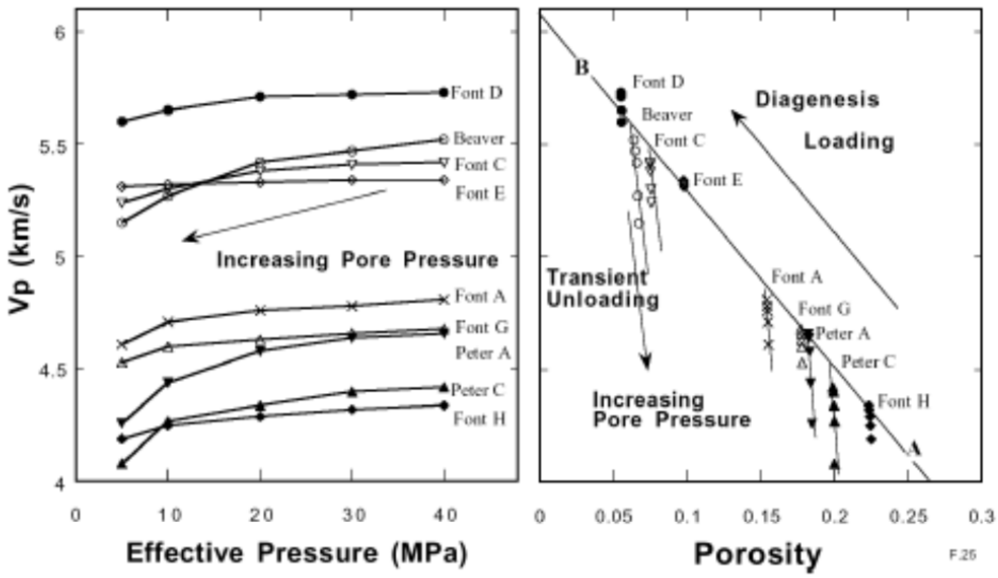
7. Source – Mavko (2008)



Stanford Rock Physics Laboratory - Gary Mavko

Parameters That Influence Seismic Velocity

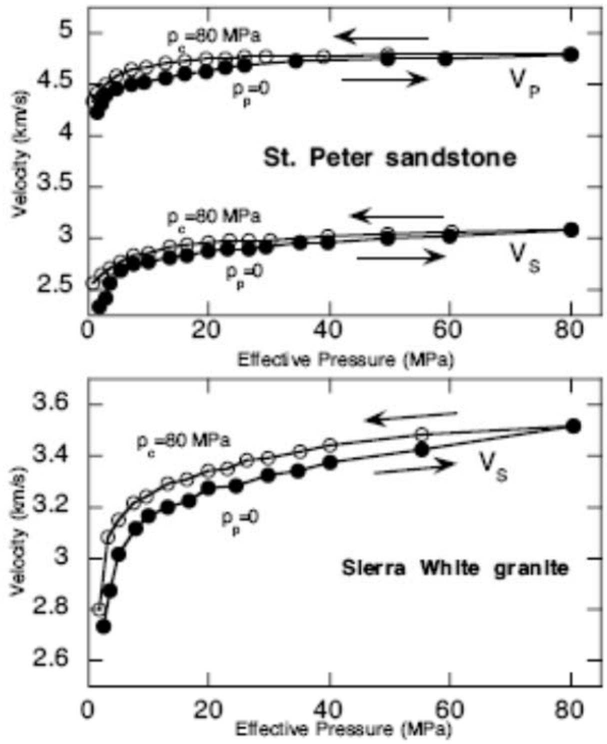
Seismic Velocity and Overpressure



Curves on the left show the typical increase of velocity with effective pressure. For each sample the velocity change is associated with the opening and closing of cracks and flaws. These are typical when rapid changes in effective pressure occur, such as during production.

Curves on the right show the same data projected on the velocity- porosity plane. Younger, high porosity sediments tend to fall on the lower right. Diagenesis and cementation tend to move samples to the upper left (lower porosity, higher velocity). One effect of over- pressure is to inhibit diagenesis, preserving porosity and slowing progress from lower right to upper left. This is called “loading” type overpressure. Rapid, late stage development of overpressure can open cracks and grain boundaries, resembling the curves on the left. This is sometimes called “transient” or “unloading” overpressure. In both cases, high pressure leads to lower velocities, but along different trends.

Parameters That Influence Seismic Velocity

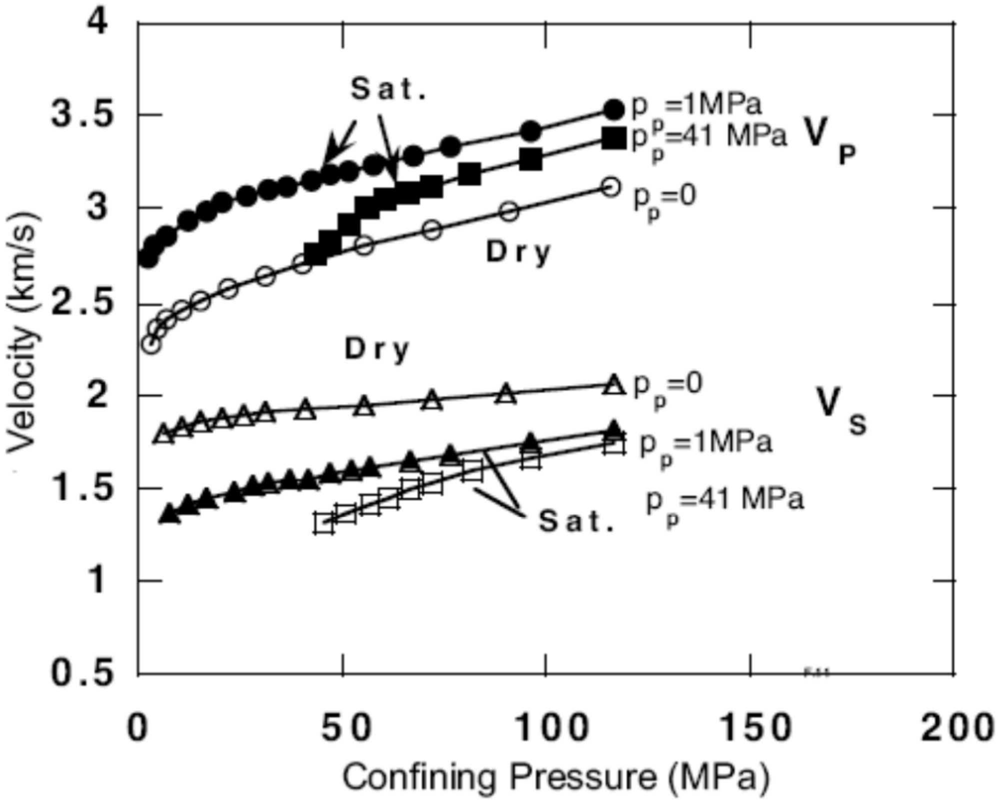


Experiments that illustrate the effective pressure law. In the first part of the experiment, effective pressure is increased by increasing confining pressure from 0 to 80 MPa, while keeping pore pressure zero (solid dots). Then, effective pressure is decreased by keeping confining pressure fixed at 80 MPa, but pumping up the pore pressure from 0 to nearly 80 MPa (open circles). (Jones,1983.)

The curves trace approximately (but not exactly) the same trend. There is some hysteresis, probably associated with frictional adjustment of crack faces and grain boundaries. For most purposes, the hysteresis is small compared to more serious difficulties measuring velocities, so we assume that the effective pressure law can be applied. This is a tremendous convenience, since most laboratory measurements are made with pore pressure equal 0.

Parameters That Influence Seismic Velocity

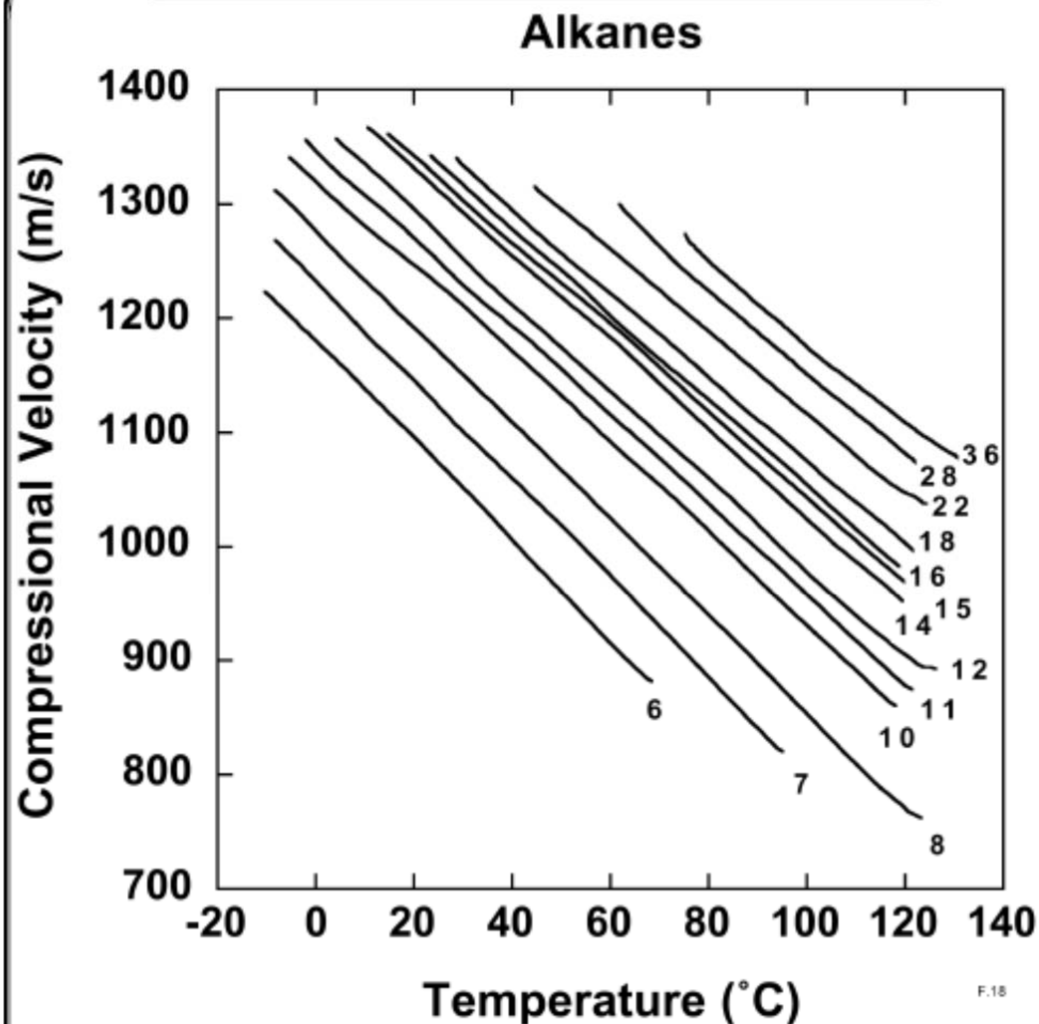
Pierre shale (ultrasonic), from Tosaya, 1982.



For shales, we also often see an increase of velocity with effective pressure. The rapid increase of velocity at low pressures is somewhat elastic, analogous to the closing of cracks and grain boundaries that we expect in sandstones.

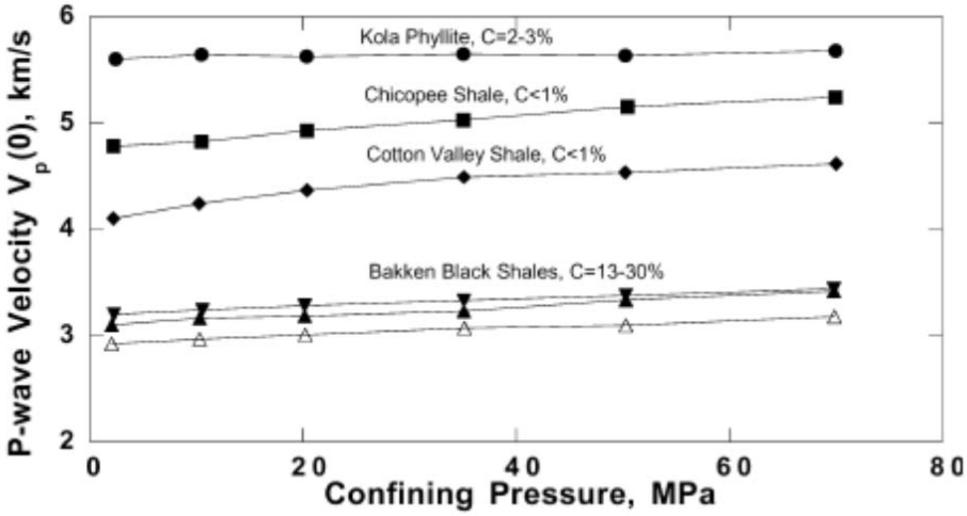
The high pressure asymptotic behavior shows a continued increase in velocity rather than a flat limit. This is probably due to permanent plastic deformation of the shale.

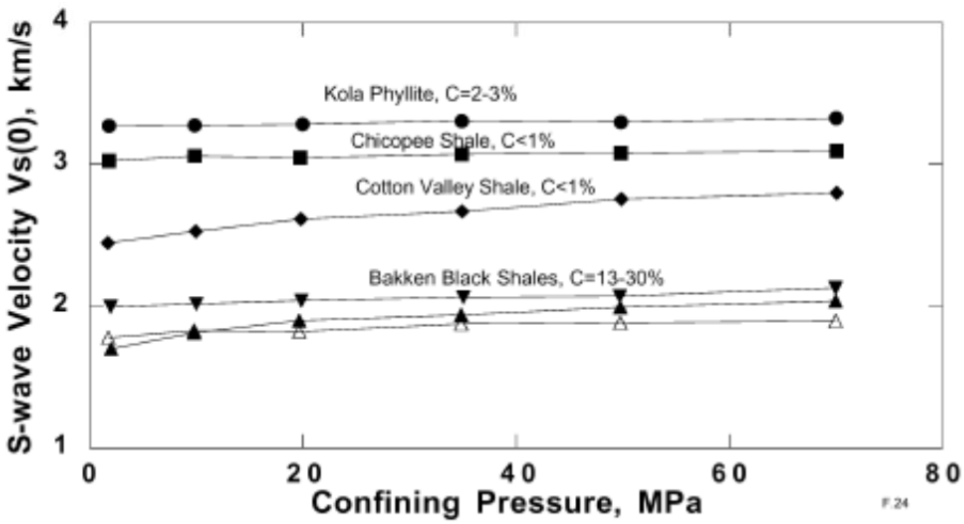
Parameters That Influence Seismic Velocity



Compressional velocities in the n-Alkanes vs. temperature. A drastic decrease of velocity with temperature! The numbers in the figure represent carbon numbers. From Wang, 1988, Ph.D. dissertation, Stanford University.

Parameters That Influence Seismic Velocity





Velocities in kerogen-rich Bakken shales (Vemik, 1990) and other low porosity argillaceous rocks (Lo et al., 1985; Tosaya, 1982; Vernik et al., 1987). Compiled by Vernik, 1990.

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Baseline Conceptual Model