APPENDIXES

APPENDIX 1: CUTTINGS AND CORE DESCRIPTIONS FOR THE DMW1 MONITORING SITE

The well cuttings were collected every 10 ft during the drilling of the borehole. These cuttings were analyzed with microscopic inspection for general lithologic features and are summarized in table A1.1. Texture was determined on all cuttings using a method developed by Folk (1954), and particle-size descriptions follow the National Research Council (1947) classification. This classification allows for the correlation of general grain-size terms (such as "sand") with size limits determined in millimeters or inches. Color, determined on wet cuttings, follows the numerical designation in the Munsell Soil Color Charts (Munsell Color, 1975).

The cores were obtained with a wire-line coring system that pushed a core barrel through the sediments ahead of the drill bit and drilling pipe to cut relatively undisturbed cylinders of sediments. The wire-line system allowed coring to be performed without removing the drilling pipe. A plastic liner was placed inside the steel core barrel to receive the cylinder of sediments. Each coring retrieved a cylinder of sediment that was as much as 5 ft in length. The cores were sealed and stored until the core measurements were completed. The coring was performed selectively during the drilling with an attempt to retrieve sediments that would contain fossils for dating the sediments as well as sediments that would be representative of the water-bearing zones.

Of the 20 2.5-inch-diameter cores that were attempted, 17 cores—a total of 73.8 ft—were recovered. The whole cores were first analyzed with a multi-sensor logger for acoustic velocity, density, and magnetic susceptibility. The multi-sensor logger data are shown with the core photographs in appendix 1 (fig. A1.1). The cores were then split, photographed, described (fig. 5), and sampled for pore-water samples, mega fossils, and micro-fossils.

The multi-sensor logger data include primary-wave velocities derived from an acoustic transducer source, bulk density derived from active gamma radiation, magnetic susceptibility, and an estimated acoustic impedance. These data provide a baseline for integration with other onshore and offshore geophysical data and provide basic estimates that will be needed by future geologic and hydrologic studies of the deep-aquifer system. These data are summarized for each core with the core photo in the following set of figures (fig. A1.1).

The multi-sensor logger data indicate that the velocities vary with clay content: velocities were on the order of 1.6 km/s (kilometer per second) in the clay-rich intervals (for example, cores 1 and 7) and 1.9 km/s for the compacted coarse sands (for example, cores 1, 15, and 18) (fig. A1.1). The discontinuities in the velocity data are caused by regions where the transducers were not in contact with the core material. Densities range from 1.7 to 2.2 g/cm^3 (gram per cubic centimeter) for the shallower sediments of core 1 (822–824.5 ft bls) and 2.5 g/cm^3 for the deepest core, core 19 (1,992–1,997 ft bls). The magnetic susceptibility is generally correlated with the ferromagnetic material that is concentrated in the silt-sized material. The acoustic impedances, which are the product of the density and the acoustic velocity, average about 3.57 km-g/s-cm^3 (kilometers-grams per second-centimeter cubed). These values show limited variation ranging from 2.01 km-g/s-cm^3 (core 16) to 4.09 km-g/s-cm^3 (core 15).

Table A1.1. Lithologic log for deep-aquifer system monitoring-well site DMW1, 14S/1E-24L2–5

[Altitude of land surface, approximately 55.6 ft. Depth is in feet below land surface. Soil and rock color notation from Munsell Color (1975). Drilled by U.S. Geological Survey Western Region Research Drilling Unit, using mud-rotary, April–May 2000. Total depth drilled: 2,012 ft. Screened intervals: 930–950; 1,040–1,060; 1,410–1,430; 1,820–1,860 ft]

Depth (ft)		Description
From	To	
0	60	Quartz sand, mainly coarse to fine quartz sand; well sorted; subrounded to well-rounded; pale yellow (5Y 7/3)
60	70	Quartz sand, mainly very coarse to fine quartz sand; well sorted; subrounded to well-rounded; pale yellow (5Y 7/3)
70	80	Slightly gravelly quartz sand, mainly very coarse to fine quartz sand with some minor quartz granules; moderately sorted; subrounded to rounded; pale yellow (2.5Y 7/3)
80	90	Gravelly quartz sand, mainly very coarse to very fine quartz sand with some quartz granules; moderately sorted; subangular to rounded; pale yellow (5Y 7/4)
90	110	Gravelly silty quartz sand, mainly very coarse to very fine quartz sand with some granule to small pebble-sized quartz gravel and minor silt; poorly sorted; subrounded to rounded; light olive gray (5Y 6/2)
110	120	Gravelly silty quartz sand, mainly very coarse to very fine quartz sand with some granule to small pebble-sized quartz gravel and silt; poorly sorted; subrounded to rounded; light olive gray (5Y 6/2)
120	130	Silty sandy gravel, mainly granular to large pebble-sized gravel; very coarse to very fine sand and some silt; poorly sorted; angular to subrounded; olive gray (5Y 5/2)
130	140	Sandy silt, silt with very coarse to very fine sand; well sorted; subangular to subrounded; pale olive (5Y 6/3)
140	150	Gravelly silty quartz sand, very coarse to very fine quartz sand with minor granule-sized gravel and some minor silt; moderately sorted; angular to subrounded; olive (5Y 5/3)
150	160	Slightly gravelly silty quartz sand, very coarse to very fine quartz sand, slightly granular with some silt; moderately sorted; angular to subrounded olive (5Y 5/3)
160	170	Silty sand, slightly coarse to very fine sand with some silt; well sorted; subrounded to well-rounded; olive (5Y 5/3)
170	180	Clayey sand silt, silt with some clay and fine to very fine sand; well sorted; subangular to subrounded; olive (5Y 5/3)
180	190	Gravelly silty sand, very coarse to fine quartz sand with granular to large pebble-sized quartz gravel and silt; moderately sorted; subangular to rounded; olive (5Y 5/3)
190	200	Silty sandy gravel, granular to medium pebble-sized gravel, very coarse to very fine and some minor silty poorly sorted; angular to subrounded; pale olive (5 5/2)
200	220	Silty sandy gravel, granular to medium pebble-sized gravel with very coarse to very fine sand with some minor silt; poorly sorted; subangular to rounded; olive gray (5Y 5/2)
220	230	Gravelly clayey sand, very coarse to fine sand with minor granule to medium pebble-sized gravel and clay; poorly sorted; subangular to rounded; pale olive (5Y 6/3)
230	240	Slightly gravelly sandy silty clay, clay with minor granule to medium pebble-sized gravel, coarse to very fine sand and silt; poorly sorted; subangular to subrounded; olive (5Y 5/3)
240	250	Slightly gravelly sandy silty clay, clay with minor granule to small pebble-sized gravel, very coarse to very fine sand and silt; poorly sorted; subrounded; olive gray (5Y 5/2) to olive (5Y 5/3)
250	260	Sandy clayey silt, silt with coarse to very fine sand and some clay; moderately sorted; subrounded to rounded; olive gray (5Y 5/2)
260	280	Gravelly silty sand, very coarse to very fine sand with some granule to medium pebble-sized gravel and silt; poorly sorted; angular to subrounded; olive gray (5Y 5/2) to olive (5Y 5/3)
280	290	Silty sand, very coarse to very fine sand with some silt; well sorted; angular to subrounded; pale olive (5Y 6/3)
290	300	Slightly gravelly silty sand, very coarse to very fine sand with some silt; moderately sorted; angular to subrounded; light yellowish brown (2.5Y 6/3)
300	310	Gravelly sand, very coarse to fine sand with some granule to medium pebble-sized gravel; poorly sorted; angular to subrounded; light yellowish brown (2.5Y 6/3)
310	320	Gravelly silty sand, very coarse to very fine sand with granules to medium pebble-sized gravel and silt; moderately sorted; subangular to subrounded; light brownish gray (2.5Y 6/2)

Table A1.1. Lithologic log for deep-aquifer system monitoring-well site DMW1, 14S/1E-24L2–5—Continued

Depth (ft)		Description
From	To	
320	325	Sandy silty clay, clay with some coarse to medium sand and silt; well sorted; subangular to subrounded; olive (5Y 5/3)
325	340	Sandy silty clay, clay with some very coarse to medium sand and silt; well sorted; subangular to subrounded; olive (5Y 5/3)
340	350	Sandy clayey silt, silt with some coarse to medium sand and clay; well sorted; subrounded; light olive brown (2.5Y 5/3)
350	370	Sandy clayey silt, silt with coarse to fine sand and clay; well sorted; subrounded; light olive brown (2.5Y 5/4)
370	380	Clayey silty sand, very coarse to fine sand with silt and clay matrix; well sorted; subangular to rounded; light yellowish brown (2.5Y 6/3)
380	390	Gravelly silty sand, very coarse to fine sand with minor granule to small pebble-sized gravel and silt; moderately sorted; subangular to rounded; light olive gray (5Y 6/2)
390	400	Slightly gravelly silty sand, very coarse to medium sand with minor granule to small pebble-sized gravel and silt; well sorted; subrounded to rounded; light yellowish brown (2.5Y 6/3)
400	410	Slightly gravelly silty sand, very coarse to medium sand with minor granule to small pebble-sized gravel and silt; well sorted; subangular to rounded; light yellowish brown (2.5Y 6/3)
410	420	Slightly gravelly silty sand, very coarse to fine sand with minor granule to small pebble-sized gravel and silt; moderately sorted; angular to subrounded; light yellowish brown (2.5Y 5/3)
420	430	Slightly gravelly silty sand, very coarse to very fine sand with minor granule to small pebble-sized gravel with silt, and some organic material (plant/wood); moderately sorted; subangular to rounded; light olive brown (2.5Y 5/3)
430	440	Silty sand, very coarse to fine sand with silt; well sorted; angular to rounded; light olive brown (2.5Y 5/3)
440	460	Silty sand, coarse to very fine sand with silt; well sorted; subangular to rounded; olive brown (2.5Y 4/3)
460	470	Clayey silty sand, very coarse to very fine sand with a silt and clay matrix; well sorted; subangular to rounded; light olive brown (2.5Y 5/3)
470	480	Silty sand, medium to very fine sand and silt; well sorted; subangular to rounded; light olive brown (2.5Y 5/3)
480	490	Silty sand, coarse to very fine sand and silt; well sorted; subangular to subrounded; olive brown (2.5Y 4/3)
490	500	Clayey silty sand, medium to very fine sand with silt and some minor clay; well sorted; subangular to subrounded; light olive brown (2.5Y 5/3)
500	510	Gravelly silty quartz sand, very coarse to fine quartz sand with minor silt and some granules to medium pebble-sized gravel; well sorted; angular to subrounded; grayish brown (2.5Y 5/2)
510	520	Silty quartz sand, very coarse to fine quartz sand with minor silt; well sorted; rounded to well rounded; olive gray (5Y 5/2)
520	530	Silty sand, fine to very fine sand with silt; well sorted; subangular to rounded; light olive brown (2.5Y 5/3)
530	540	Silty sand, coarse to very fine sand with silt; well sorted; subangular to rounded; olive brown (2.5Y 4/3)
540	550	Clayey silty sand, fine to very fine sand with silt and minor clay; well sorted; subrounded to rounded; brown (7.5YR 4/4)
550	560	Silty sand, fine to very fine sand with silt; well sorted; subangular to rounded; brown (7.5YR 4/4)
560	570	Gravelly silty sand, very coarse to very fine sand, slightly granular with silt; moderately sorted; rounded to well rounded; light olive brown (2.5Y 5/3)
570	580	Gravelly silty sand, very coarse to very fine sand with granule to small pebble-sized gravel with silt; moderately sorted; well rounded; light olive brown (2.5Y 5/3)
580	590	Silty sand, very coarse to very fine sand with silt; moderately sorted; subrounded to rounded; light yellowish brown (2.5Y 6/3)
590	600	Gravelly silty sand, very coarse to minor very fine sand, granular with some minor silt; very well-sorted; rounded to well-rounded; light olive brown (2.5Y 5/3)
600	610	Gravelly silty sand, medium to very fine sand, granular with silt; moderately sorted; subrounded to rounded; light olive brown (2.5Y 5/3)

Table A1.1. Lithologic log for deep-aquifer system monitoring-well site DMW1, 14S/1E-24L2–5—Continued

Depth (ft)		Description
From	To	
610	620	Gravelly silty sand, very coarse to very fine sand, slightly granular with some silt; moderately sorted; subrounded to rounded; light yellowish brown (2.5Y 6/3)
620	630	Gravelly silty sand, very coarse to very fine sand, occasional granule to medium pebble-sized gravel with silt; moderately sorted; subrounded to rounded; light olive brown (2.5Y 5/3)
630	640	Silty sand, medium to very fine sand with silt; very well sorted; subrounded to well-rounded; olive brown (2.5Y 4/3)
640	650	Silty sand, coarse to very fine sand with silt; well sorted; subrounded to rounded; light olive brown (2.5Y 5/3)
650	660	Gravelly silty sand, very coarse to fine sand with occasional granules and some silt; well sorted; rounded to well-rounded; light olive brown (2.5Y 5/3)
660	670	Gravelly silty sand, very coarse to fine sand with occasional granules and some silt; well sorted; rounded to well-rounded; light olive brown (2.5Y 5/3)
670	680	Gravelly silty sand, very coarse to medium sand with granules to medium pebble-sized gravel with silt; moderately sorted; subangular to rounded; light olive brown (2.5Y 5/3)
680	690	Gravelly silty sand, very coarse to fine sand with granules to medium pebble-sized gravel and minor silt; moderately sorted; subangular to rounded; light olive brown (2.5Y 5/4)
690	700	Slightly gravelly sand, very coarse to fine sand, occasionally granular; well sorted; subrounded to rounded; light olive brown (2.5Y 5/3)
700	710	Sandy silty clay, clay with some silt and very coarse to medium sand; moderately sorted; subangular to subrounded; light olive brown (2.5Y 5/4)
710	720	Sandy silty clay, clay with some silt and very coarse to medium sand; moderately sorted; subangular to rounded; light olive brown (2.5Y 5/4)
720	730	Sandy silty clay, clay with some silt and medium to very fine sand; well sorted; subrounded to rounded; light olive brown (2.5Y 5/4)
730	740	Sandy silty clay, clay with some silt and fine to very fine sand; well sorted; subangular to subrounded; light olive brown (2.5Y 5/3)
740	750	Sandy silty clay, clay with silt and some fine to very fine sand; well sorted; subangular to subrounded; grayish brown (2.5Y 5/2)
750	760	Sandy silty clay, clay with abundant silt and some very fine sand; well sorted; subangular to subrounded; olive gray (5y 5/2)
760	770	Sandy silty clay, clay with abundant silt and some fine to very fine sand; well sorted; subangular to subrounded; olive gray (5Y 4/2)
770	780	Sandy silty clay, clay with abundant silt and some fine to very fine sand; well sorted; subangular to subrounded; olive (5Y 5/3)
780	790	Sandy silty clay, clay with silt and very coarse to very fine sand; moderately sorted; subangular to subrounded; olive (5Y 5/3)
790	800	Sandy silty clay, clay with silt and very coarse to very fine sand; moderately sorted; subangular; olive (5Y 5/3)
800	810	Silty clay, clay with some silt; well sorted; subangular to subrounded; pale olive (5Y 6/3)
810	820	Sandy silty clay, clay with silt and medium to very fine sand; moderately sorted; subangular to subrounded; olive (5Y 5/3)
Core 1 (822–825)		
820	830	Sandy silty clay, clay with silt and medium to very fine sand, grains mainly quartz with <1% mica (biotite); moderately sorted; subangular to subrounded; olive (5Y 5/3)
830	840	Sandy silty clay, clay with silt and medium to very fine sand; moderately sorted; subangular to subrounded; olive (5Y 5/3); accessory: chips contain clay, silt and fine to very fine sand [mainly quartz sand with <1% mica (biotite)]
840	850	Sandy silty clay, clay with silt and coarse to very fine sand; moderately sorted; subangular to well rounded; olive (5Y 5/3); accessory: chips contain clay, silt and medium to very fine sand [mainly quartz sand with <1% mica (biotite)]

Table A1.1. Lithologic log for deep-aquifer system monitoring-well site DMW1, 14S/1E-24L2–5—Continued

Depth (ft)		Description
From	To	
850	860	Sandy silty clay with silt and medium to very fine sand; moderately sorted; subangular to subrounded; olive (5Y 5/3); accessory: chips contain clay, silt and fine to very fine sand [mainly quartz sand with <1% mica (biotite)]
860	870	Sandy silty clay, clay with silt and medium to very fine sand; well sorted; subangular to subrounded; olive (5Y 5/3); grains mainly quartz with <1% mica (biotite)
870	880	Sandy silty clay, clay with silt and very coarse to very fine sand; moderately sorted; subangular to subrounded; olive (5Y 5/3); grains mainly quartz with >1% mica (biotite)
880	890	Sandy silty clay, clay with silt and very coarse to very fine sand; moderately sorted; subangular to subrounded; light yellowish brown (2.5Y 6/3); grains mainly quartz with <1% mica (biotite)
890	895	Sandy silty clay, clay with silt and very coarse to very fine sand, moderately sorted; subangular to subrounded; olive gray (2.5Y 6/3); accessory chips contain clay, silt and coarse to very fine sand, grains mainly quartz with <1% mica (biotite); olive gray (5Y 5/2)
895	900	Sandy silty clay, clay with silt and very coarse to very fine sand; moderately sorted; subangular to subrounded; pale olive (5Y 6/3); accessory chips contain clay, silt and medium to very fine sand, grains mainly quartz with <1% mica (biotite); olive gray (5Y 8/2)
900	905	Slightly gravelly sandy silty clay, clay with silt, very coarse to very fine sand and slightly granular; moderately sorted; subangular to subrounded; olive gray (5Y 5/2); grains mainly quartz with <1% mica (biotite)
905	910	Sandy silty clay, clay with silt and very coarse to very fine sand; moderately sorted; subangular to subrounded; light yellowish brown (2.5Y 6/3); grains mainly quartz
910	915	Sandy silty clay, clay with silt and very coarse to very fine sand; moderately sorted; subangular to subrounded; light yellowish brown (2.5Y 6/3); grains mainly quartz with <1% mica
915	920	Sandy silty clay, clay with silt and very coarse to very fine sand; moderately sorted; subangular to rounded; pale olive (5Y 6/3); grains mainly quartz
Core 2 (922–927), Core 3 (927–932), Core 4 (932–937), Core 5 (937–942)		
920	945	Clayey silty quartz sand, coarse to very fine sand with some silt and clay; well sorted; subangular to rounded; light olive brown (2.5Y 5/3)
945	950	Clayey silty quartz sand, very coarse to very fine quartz sand with some silt and clay; well sorted; subrounded to well rounded; light olive brown (2.5Y 5/3)
950	955	Clayey silty quartz sand, very coarse to very fine quartz sand with some silt and minor clay; well sorted; subrounded to well rounded; light olive brown (2.5Y 5/3)
955	960	Clayey silty quartz sand, very coarse to very fine quartz sand with silt and clay; well sorted; subangular to rounded; olive gray (5Y 5/2); accessory: grains <1% mica (biotite)
960	965	Clayey silty quartz sand, very coarse to very fine sand with silt and clay; well sorted; subangular to subrounded; olive gray (5Y 5/2); accessory: grains <1% mica (biotite)
965	970	Sandy silty clay, clay with silt and some medium to very fine quartz sand; well sorted; subangular to subrounded; dark gray (5Y 4/1)
970	975	Sandy clayey silt, silt with clay and some medium to very fine quartz sand; well sorted; subangular to rounded; dark gray (5Y 4/1)
975	980	Sandy silty clay, clay with abundant silt and fine to very fine quartz sand; well sorted; subangular to subrounded; dark gray (5Y 4/1)
980	985	Sandy clayey silt, silt with some clay and coarse to very fine sand; moderately sorted; subangular to subrounded; dark gray (5Y 4/1)
985	990	Sandy silty clay, clay with abundant silt and fine to very fine quartz sand; well sorted; subangular; dark gray (5Y 4/1)
990	995	Sandy clayey silt, silt with clay and coarse to very fine quartz sand; well sorted; subangular to rounded; dark gray (5Y 4/1)
995	1,000	Sandy silty clay, clay with silt and coarse to very fine sand; moderately sorted; subangular to subrounded; dark gray (5Y 4/1); grains mainly quartz with <1% mica (biotite)
1,000	1,005	Sandy silty clay, clay with silt and coarse to very fine sand; moderately sorted; subangular to subrounded; dark gray (5Y 4/1)

Table A1.1. Lithologic log for deep-aquifer system monitoring-well site DMW1, 14S/1E-24L2–5—Continued

Depth (ft)		Description
From	To	
1,005	1,010	Sandy silty clay, clay with silt and medium to very fine quartz sand; well sorted; subangular to rounded; dark gray (5Y 4/1); accessory: some small shell fragments
1,010	1,015	Sandy silty clay, clay with abundant silt and medium to very fine quartz sand; well sorted; subangular to subrounded; dark gray (5Y 4/1); accessory: small shell fragment and <1% mica (biotite?)
1,015	1,020	Sandy clayey silt, silt with some clay and fine to very fine quartz sand; well sorted; subangular to rounded; dark gray (5Y 4/1); accessory: ~1% mica (biotite)
1,020	1,025	Sandy clayey silt, silt with some clay and medium to very fine quartz sand; moderately sorted; subangular to rounded; dark gray (5Y 4/1); accessory: granule size shell and wood fragments and <1% mica (biotite)
1,025	1,030	Sandy clayey silt, silt with some clay and medium to very fine quartz sand; moderately sorted; subangular to rounded; olive gray (5Y 4/2); accessory: granule-sized shell and wood fragments and <1% mica (biotite)
1,030	1,035	Sandy clayey silt with some clay and very coarse to very fine quartz sand; moderately sorted; subangular to rounded; dark gray (5Y 4/1)
1,035	1,040	Clayey sandy silt, silt with some clay and very coarse to very fine quartz sand; moderately sorted; subangular to rounded; dark gray (5Y 4/1)
Core 6 (1,042–1,047)		
1,040	1,050	Clayey silty sand, very coarse to very fine sand with some clay and silt; moderately sorted; subangular to subrounded; light olive brown (2.5Y 5/3); accessory: <1% mica (biotite)
1,050	1,055	Clayey silty sand, very coarse to very fine sand with some clay and silt; moderately sorted; subangular to subrounded; grayish brown (2.5Y 5/2)
1,055	1,060	Clayey silty sand, coarse to very fine sand with some clay and silt; moderately sorted; subangular to subrounded; olive gray (5Y 4/2); accessory: <1% mica
1,060	1,065	Sandy clayey silt, silt with clay and very coarse to very sand; moderately sorted; subangular to rounded; olive gray (5Y 5/2); accessory: <1% mica
1,065	1,070	Sandy clayey silt, silt with clay and coarse to very fine sand; well sorted; subangular to subrounded; olive gray (5Y 4/2); accessory: <1% mica
1,070	1,075	Clayey silty sand, medium to very fine sand with silt and clay; well sorted; subangular to subrounded; grayish brown (2.5Y 5.2); accessory: <1% mica; silty clay chips; dark greenish gray (10GY 4/1)
1,075	1,080	Clayey silty sand, fine to very fine sand with some clay and silt; well sorted; subangular to subrounded; dark gray (5Y 4/1)
1,080	1,085	Clayey silty sand, fine to very fine sand with some clay and silt; well sorted; subangular to subrounded; dark gray (5Y 4/1)
1,085	1,090	Clayey silty sand, very coarse to very fine sand with clay and silt; moderately sorted; subangular to subrounded; dark gray (5Y 4/1); accessory: some granule to small pebble-sized shell fragments and <1% mica
1,090	1,095	Clayey silty sand, medium to very fine sand with clay and silt; well sorted; subangular to subrounded; dark gray (5Y 4/1)
1,095	1,100	Clayey silty sand, coarse to very fine sand with clay and silt; well sorted; subangular to subrounded; dark gray (5Y 4/1)
Core 7 (1,102–1,107)		
1,100	1,110	Clayey sandy silt, silt with clay and medium to very fine sand; well sorted; subangular to subrounded; dark gray (5Y 4/1); accessory: granule to small pebble-sized shell fragments
1,110	1,115	Sandy clayey silt, silt with clay and medium to very fine sand; well sorted; subangular to subrounded; dark gray (5Y 4/1)
1,115	1,120	Sandy clayey silt, silt with clay and fine to very fine sand; well sorted; subangular to subrounded; dark gray (5Y 4/1); accessory: ~1% mica (biotite)
1,120	1,125	Sandy silty clay, clay with silt and very coarse to very fine sand; moderately sorted; subangular to subrounded; dark gray (5Y 4/1); accessory: small organic material (wood?) and <1% mica
1,125	1,130	Sandy silt clay, clay with silt and medium to very fine sand; well sorted; subangular to subrounded; dark gray (5Y 4/1)

Table A1.1. Lithologic log for deep-aquifer system monitoring-well site DMW1, 14S/1E-24L2–5—Continued

Depth (ft)		Description
From	To	
1,130	1,135	Sandy silty clay, clay with silt and fine to very fine sand; well sorted; subangular to rounded; dark gray (5Y 4/1); accessory: <1% mica
1,135	1,140	Slightly sandy silty clay, clay with abundant silt and some very fine sand; well sorted; subangular to subrounded; dark gray (5Y 4/1); accessory: some coarse sized shell fragments and <1% mica
1,140	1,150	Sandy silty clay; clay with silt and medium to very fine sand; well sorted; subangular to rounded; dark gray (5Y 4/1); accessory: <1% (biotite)
1,150	1,155	Sandy clayey silt, silt with clay and medium to very fine sand; well sorted; subangular to subrounded; dark gray (5Y 4/1); accessory: fine shell fragments and <1% mica
1,155	1,160	Sandy clayey silt, silt with clay and medium to very fine sand; well sorted; subangular to rounded; dark gray (5Y 4/1); accessory: <1% mica (biotite)
1,160	1,165	Sandy clayey silt, silt with clay and medium to very fine sand; well sorted; subangular to subrounded; dark gray (5Y 4/1); accessory: <1% mica (biotite)
1,165	1,170	Sandy silty clay, clay with silt and coarse to very fine sand; moderately sorted; subangular to well rounded; dark gray (5Y 4/1); accessory: coarse-sized shell fragments and <1% mica
1,170	1,175	Sandy silty clay, clay with abundant silt and medium to very fine sand; well sorted; subangular to rounded; dark gray (5Y 4/1); accessory: coarse-sized shell fragments
1,175	1,180	Sandy clayey silt, silt with some clay and medium to very fine sand; well sorted; subangular to subrounded; dark gray (10Y 4/1); accessory: <1% mica
1,180	1,185	Sandy clayey silt, silt with abundant clay and fine to very fine sand; well sorted; subangular to subrounded; dark greenish gray (10Y 4/1); accessory: <1% mica
1,185	1,190	Slightly sandy silty clay, clay with silt and minor very fine sand; very well-sorted; subangular to subrounded; dark greenish gray (10Y 4/1)
1,190	1,195	Slightly sandy silty clay, clay with silt and minor very coarse to very fine sand; moderately sorted; subangular to subrounded; dark greenish gray (10Y 4/1)
1,195	1,205	Slightly sandy silty clay, clay with minor silt and minor fine to very fine sand; very well-sorted; subangular; dark greenish gray (10Y 4/1); accessory: <1% mica
1,205	1,217	Slightly silty sand, mainly fine to very fine quartz sand with some very minor silt; well sorted; angular to well rounded; dark olive gray (5Y 3/2); accessory grains include: biotite and feldspar
Core 8 (1,212–1,217), Core 9 Shoe Sample only (1,217)		
1,217	1,220	Sandy clayey silt, silt with some clay and very fine sand; well sorted; subangular to subrounded; dark gray (5Y 4/1)
1,220	1,225	Sandy silt, silt with fine to very fine sand; well sorted; subangular to subrounded; dark greenish gray (10Y 4/1)
1,225	1,230	Clayey sandy silt, silt with some clay and fine very fine sand; well sorted; subangular; dark gray (5Y 4/1); <1% mica (biotite)
1,230	1,235	Sandy clayey silt, silt with clay and fine to very fine sand; well sorted; subangular to subrounded; dark gray (5Y 4/1)
1,235	1,240	Sandy clayey silt, silt with clay and fine to very fine sand; well sorted; subangular to subrounded; dark gray (5Y 4/1)
1,240	1,245	Sandy clayey silt, silt with clay and fine to very fine sand; well sorted; subangular to subrounded; dark gray (5Y 4/1)
1,245	1,250	Sandy clayey silt, silt with clay and fine to very fine sand; well sorted; subangular to subrounded; olive gray (5Y 4/2)
1,250	1,255	Sandy clayey silt, silt with clay and fine to very fine sand; well sorted; subangular to subrounded; dark gray (5Y 4/1)
Core 10 (1,262–1,267)		
1,255	1,267	Sandy clayey silt, silt with clay and fine to very fine sand; well sorted; subangular to subrounded; dark gray (5Y 4/1)

Table A1.1. Lithologic log for deep-aquifer system monitoring-well site DMW1, 14S/1E-24L2–5—Continued

Depth (ft)		Description
From	To	
Core 11 (1,267–1,272)		
1,267	1,272	Sand, fine to very fine sand; mostly quartz; well sorted; subangular to well rounded; dark greenish gray (10Y 4/1)
Core 12 (1,272–1,277)		
1,272	1,275	Clayey sandy silt, silt with some clay and medium to very fine sand; well sorted; subangular to subrounded; olive (5Y 4/3); accessory: small pebble-sized shell fragments
1,275	1,280	Clayey silty sand, medium to very fine sand with clay and abundant silt; well sorted; subangular to rounded; olive gray (5Y 4/2); accessory: medium pebble-sized shell fragments
1,280	1,285	Sandy silty clay, clay with abundant silt and coarse to very fine sand; moderately sorted; subangular to rounded; dark gray (5Y 4/1)
1,285	1,290	Sandy silty clay, clay with abundant silt and medium to very fine sand; well sorted; subangular to rounded; dark greenish gray (10Y 4/1); accessory: medium sand-sized shell fragments
1,290	1,295	Sandy silty clay, clay with abundant silt and fine to very fine sand; well sorted; subrounded to rounded; dark greenish gray (10Y 4/1)
1,295	1,300	Slightly sandy silty clay, clay with silt and minor fine to very fine sand; well sorted; subangular to subrounded; dark greenish gray (10Y 4/1); accessory: <1% mica
1,300	1,305	Slightly sandy silty clay, clay with abundant silt and minor fine to very fine sand; well sorted; subangular to subrounded; dark greenish gray (10Y 4/1)
1,305	1,310	Sandy silty clay, clay with abundant silt and fine to very fine sand; well sorted; subangular to subrounded; dark greenish gray (10Y 4/1); accessory: very coarse sand-sized shell fragments
Core 13 (1,312–1,317), Core 14 (1,317–1,322)		
1,310	1,325	Clayey sandy silt, silt with some clay and medium to very fine sand; well sorted; subangular to subrounded; dark greenish gray (10Y 4/1)
1,325	1,330	Clayey sandy silt, silt with some clay and medium to very fine sand; well sorted; subangular to well rounded; dark olive gray (5Y 3/2)
1,330	1,335	Clayey silty sand, medium to very fine sand with abundant silt and some clay; well sorted; subangular to rounded; olive (5Y 4/3); accessory: some small pebble-sized shell fragments
1,335	1,340	Clayey silty sand; medium to very fine sand with abundant silt and some clay; well sorted; subangular to subrounded; olive gray (5Y 4/2)
1,340	1,345	Sandy silt, silt with medium to very fine sand; well sorted; subangular to rounded; dark olive gray (5Y 3/2)
1,345	1,350	Silty sand, very coarse to very fine sand with silt; moderately sorted; subangular to well rounded; dark olive gray (5Y 3/2)
1,350	1,355	Gravelly silty sand, very coarse to very fine sand with abundant silt and minor granule to small pebble-sized gravel; moderately sorted; subangular to well rounded; dark greenish gray (10Y 4/1)
1,355	1,360	Gravelly silty sand, very coarse to very fine sand with granule to small pebble-sized gravel and silt; poorly sorted; subangular to rounded; olive gray (5Y 4/2)
1,360	1,365	Sandy clayey silt, silt with clay and fine to very fine sand; well sorted; subangular to subrounded; dark gray (5Y 4/1)
1,365	1,370	Sandy clayey silt, silt with clay and medium to very fine sand; well sorted; subangular to subrounded; dark gray (5Y 4/1); accessory: some coarse sand-sized shell fragments
1,370	1,375	Sandy clayey silt, silt with clay and very fine sand; well sorted; subangular to subrounded; dark olive gray (5Y 3/2); accessory: <1% mica (biotite)
1,375	1,385	Clayey sandy silt, silt with medium to very fine sand and some clay; well sorted; subangular to rounded; dark gray (5Y 4/1); accessory: <1% (biotite)
1,385	1,390	Sandy clayey silt, silt with clay and some medium to very fine sand; well sorted; subangular; dark olive gray (5Y 3/2)
1,390	1,400	Sandy clayey silt, silt with clay and very coarse to very fine sand; poorly sorted; subangular to subrounded; dark olive gray (5Y 3/2)

Table A1.1. Lithologic log for deep-aquifer system monitoring-well site DMW1, 14S/1E-24L2–5—Continued

Depth (ft)		Description
From	To	
1,400	1,410	Sandy clayey silt, silt with clay and very coarse to very fine sand; poorly sorted; angular to subrounded; dark greenish gray (10Y 4/1); accessory: some coarse sand-sized shell fragments and <1% mica
1,410	1,420	Gravelly sandy clayey silt, very coarse to very fine sand and some granule to small pebble-sized gravel; poorly sorted; subangular to subrounded; dark greenish gray (10Y 4.1); accessory: some very coarse sand-sized shell fragments
1,420	1,430	Clayey silty sand, very coarse to very fine sand with silt and clay; poorly sorted; subangular to rounded; olive gray (5Y 5/2); accessory: very coarse sand-sized shell fragments and some organic plant material
1,430	1,440	Clayey silty sand, very coarse to very fine sand with silt and clay; poorly sorted; subangular to well rounded; dark greenish gray (10Y 4/1); accessory: some organic plant material
1,440	1,450	Clayey silty sand; very coarse to very fine sand with silt and clay; poorly sorted; subangular to rounded; olive (5Y 4/3)
1,450	1,460	Clayey silty sand, very coarse to very fine sand with silt and clay; poorly sorted; subangular to well rounded; olive gray (5Y 4/2)
1,460	1,470	Sandy clayey silt, silt with clay and very coarse to very fine sand; poorly sorted; subangular to rounded; olive gray (5Y 5/2)
1,470	1,480	Sandy silty clay, clay with silt and very coarse to very fine sand; poorly sorted; subangular to well rounded; olive gray (5Y 5/2)
1,480	1,490	Gravelly sandy clayey silt, silt with clay, very coarse to very fine sand and slightly granular; poorly sorted; subangular to well rounded; dark gray (5Y 4/1)
1,490	1,520	Silty sand, medium to very fine sand with silt; moderately sorted; subangular to subrounded; dark gray (5Y 4/1)
1,520	1,540	Sandy silt, silt with fine to very fine sand; well sorted; subangular to subrounded; dark gray (5Y 4/1)
1,540	1,560	Sandy silt, silt with fine to very fine sand; well sorted; subangular to rounded; dark gray (5Y 4/1); accessory: <1% mica
1,560	1,580	Sandy silt, silt with medium to very fine sand; well sorted; subangular to rounded; dark greenish gray (10Y 4/1); accessory: ~1% mica (biotite) and some medium sand-sized calcite crystal
1,580	1,600	Sandy silt, silt with medium to very fine sand; well sorted; subangular to subrounded; dark greenish gray (10Y 4/1); accessory: ~1% mica and some medium sand-sized calcite crystals
1,600	1,620	Clayey silt, silt with clay; well sorted; subangular to subrounded; dark greenish gray (5Y 4/1)
1,620	1,640	Sandy silt clay, clay with silt and minor fine to very fine sand; well sorted; angular to subrounded; dark greenish gray (10Y 4/1); accessory: <1% mica
1,640	1,660	Silty clay, clay with silt; well sorted; subangular to subrounded; dark greenish gray (10Y 4/1); accessory: <1% mica and some calcite crystals (possibly have grown since sample was taken)
1,660	1,680	Silty clay, clay with silt; well sorted; subangular to subrounded; dark greenish gray (10Y 4/1); accessory: same calcite crystals have formed
1,680	1,700	Sandy silty clay, clay with silt and very coarse to very fine sand; poorly sorted; subangular to rounded; olive gray (5Y 4/2); accessory: same calcite crystals have formed
Core 15 (1,717–1,722)		
1,700	1,722	Quartz sand, coarse to very fine quartz sand; moderately sorted; subangular to subrounded; greenish gray (10Y 5/1)
Core 16 (1,722–1,727)		
1,722	1,727	Silty quartz sand, coarse to very fine quartz sand with silt; moderately sorted; subangular to rounded; greenish gray (10Y 5/1)
Core 17 Shoe Sample only (1,727)		
1,727	1,732	Silty quartz sand; fine to very fine quartz sand with silt; well sorted; angular to subrounded; greenish gray (5GY 6/1)
Core 18 (1,732–1,737)		
1,732	1,737	Silty quartz sand, fine to very fine quartz sand with silt; well sorted; angular to subrounded; greenish gray (5GY 6/1)

Table A1.1. Lithologic log for deep-aquifer system monitoring-well site DMW1, 14S/1E-24L2–5—Continued

Depth (ft)		Description
From	To	
1,737	1,750	Slightly gravelly silty sand, mainly fine to very fine quartz sand with silt, slightly granular; poorly sorted; angular to well rounded; greenish gray (10Y 6/1)
1,750	1,760	Gravelly silty sand, mainly very coarse to very fine quartz sand with silt and granule to small pebble-sized gravel; poorly sorted; angular to well rounded; greenish gray (10Y 5/1)
1,760	1,790	Sandy silty clay, clay with silt and very coarse to very fine sand; poorly sorted; subangular to subrounded; dark greenish gray (10Y 4/1); accessory: calcite crystals have formed
1,790	1,800	Silty clay, clay with silt; well sorted; subangular; dark greenish gray (10Y 3/1)
1,800	1,810	Slightly sandy silty clay, clay with silt and minor coarse to very fine sand; moderately sorted; subangular to rounded; dark greenish gray (10Y 3/1); accessory: calcite has formed
1,810	1,820	Silty sand, very coarse to very fine sand with silt; moderately sorted; subangular to rounded; olive (5Y 4/3)
1,820	1,830	Silty sand, very coarse to fine sand with silt; well sorted; rounded to well rounded; greenish gray (10Y 5/1)
1,830	1,860	Clayey sandy silt, silt with very coarse to very fine sand and some clay; poorly sorted; subangular to rounded; dark greenish gray (10Y 4/1)
1,860	1,870	Clayey sandy silt, silt with very coarse to very fine sand and some clay; poorly sorted; subangular to rounded; dark greenish gray (10Y 4/1)
1,870	1,880	Clayey sandy silt, silt with medium to very fine sand and some clay; moderately sorted; subangular; olive gray (5Y 4/2); accessory: <1% mica (biotite)
1,880	1,890	Clayey sandy silt; silt with very coarse to very fine sand and some small chips of clay; poorly sorted; subangular to subrounded; olive gray (5Y 4/2)
1,890	1,900	Sandy clayey silt, silt with clay and some fine to very fine sand; moderately sorted; subangular to subrounded; dark gray (5Y 4/1)
1,900	1,920	Clayey sandy silt, silt with medium to very fine sand and clay chips; moderately sorted; subangular to subrounded; olive gray (5Y 5/2); accessory: medium sand to small pebble-sized shell fragments
1,920	1,930	Sandy clayey silt, silt with clay chips and some fine to very fine sand; moderately sorted; subangular; olive gray (5Y 4/2)
1,930	1,940	Sandy silty clay, clay chips with silt and some very fine sand; well sorted; subangular to rounded; dark gray (5Y 4/1)
1,940	1,950	Slightly sandy silty clay, clay chips with silt and minor very fine sand; well sorted; subangular to subrounded; dark greenish gray (10Y 4/1); accessory: <1% mica (biotite)
1,950	1,960	Clayey sandy silt, silt with coarse to very fine sand and some clay; moderately sorted; subangular to subrounded; dark greenish gray (10Y 4/1)
1,960	1,980	Silty clay, clay with silt; well sorted; angular to subrounded; olive gray (5Y 4/2)
Core 19 (1,992–1,997)—No samples taken 1,997–2,012		

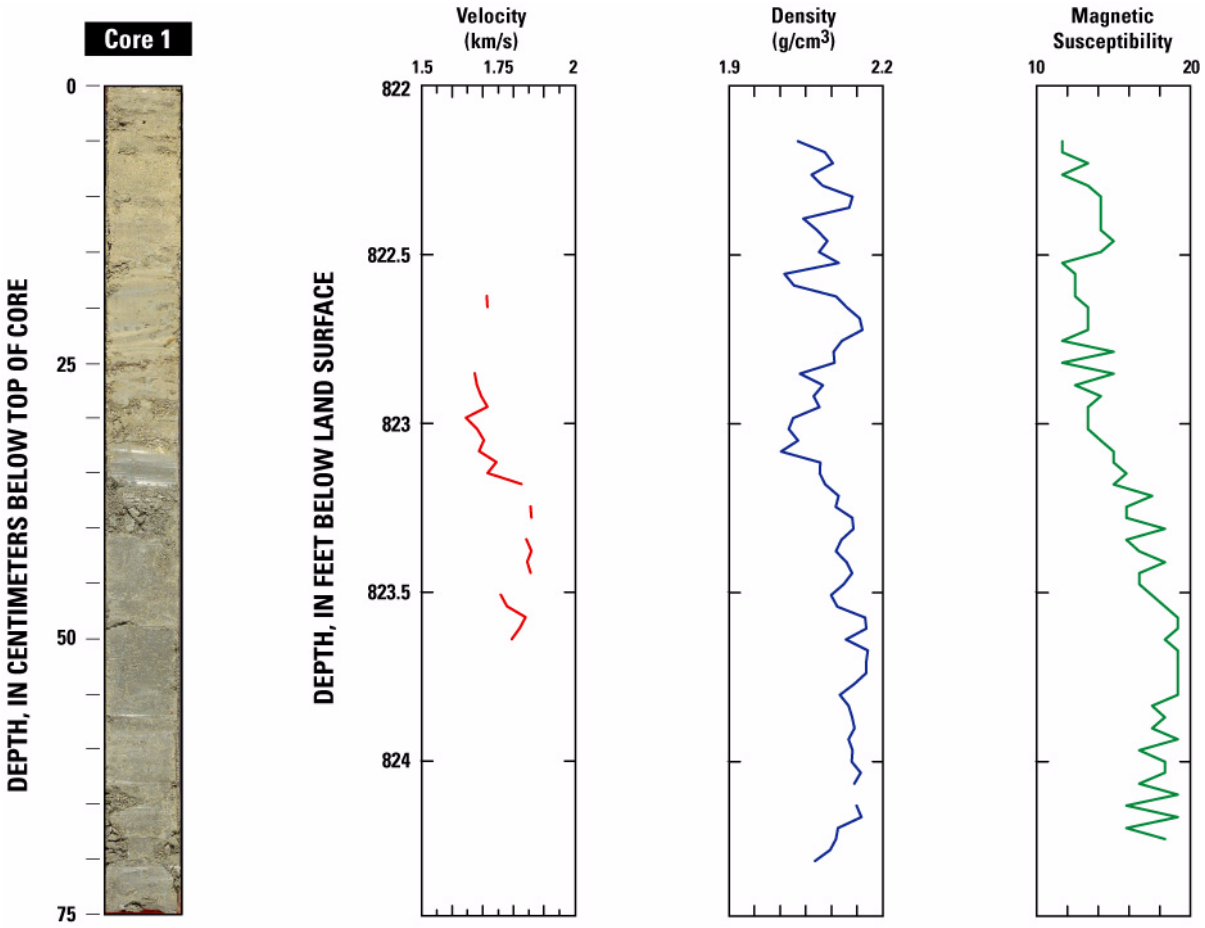

Figure A1.1. Core 1 description.

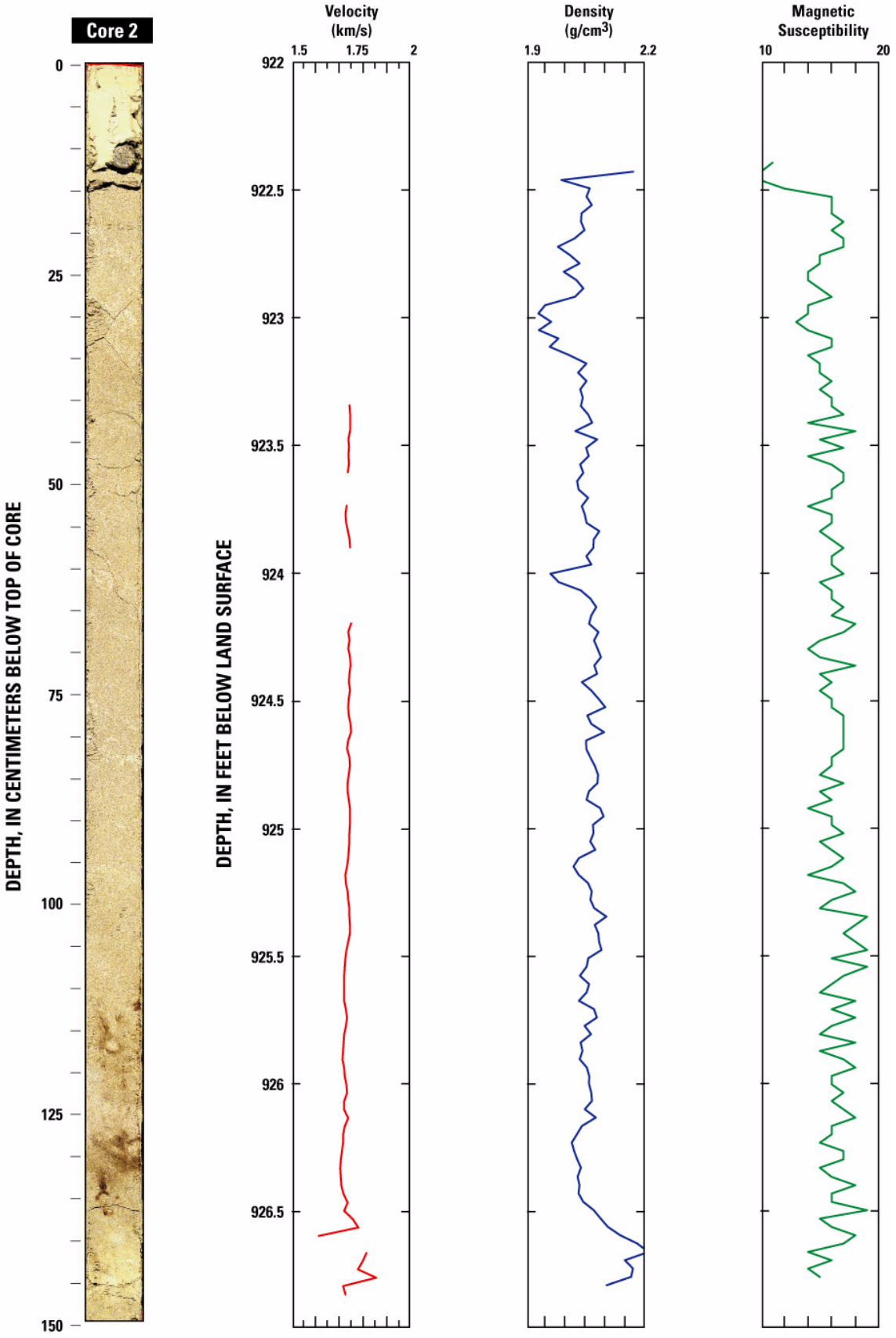

Figure A1.1. Core 2 description.

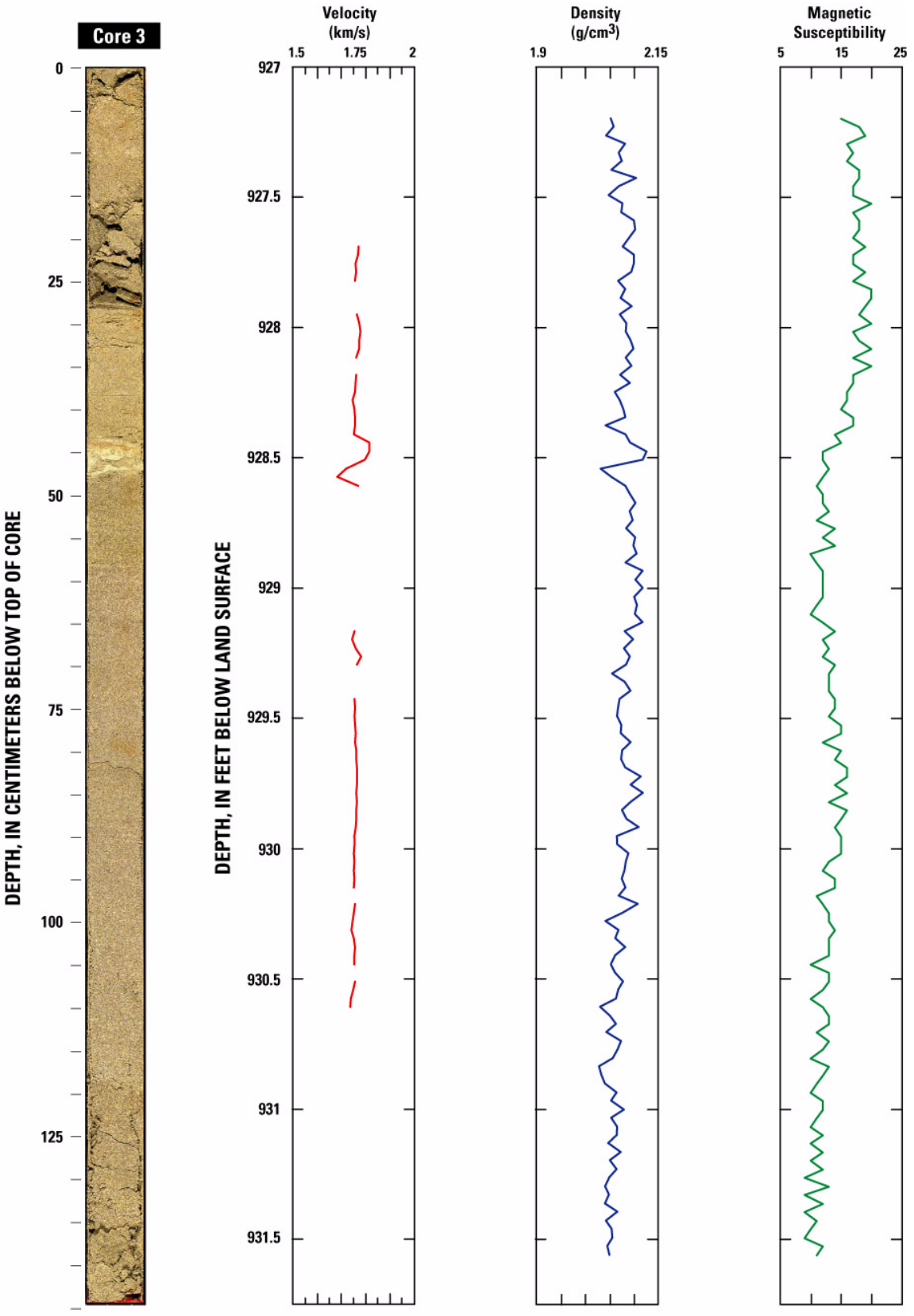

Figure A1.1. Core 3 description.

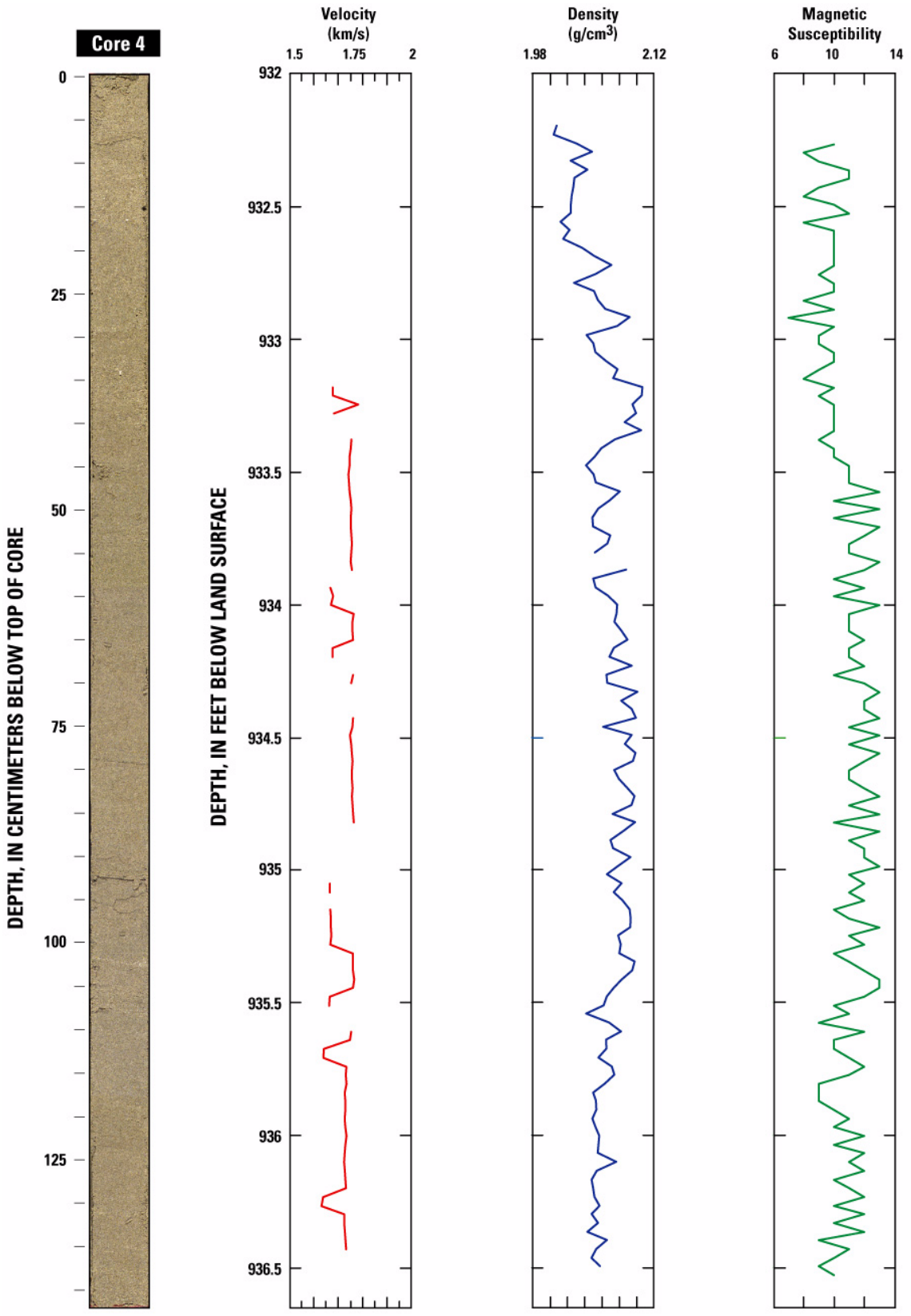

Figure A1.1. Core 4 description.

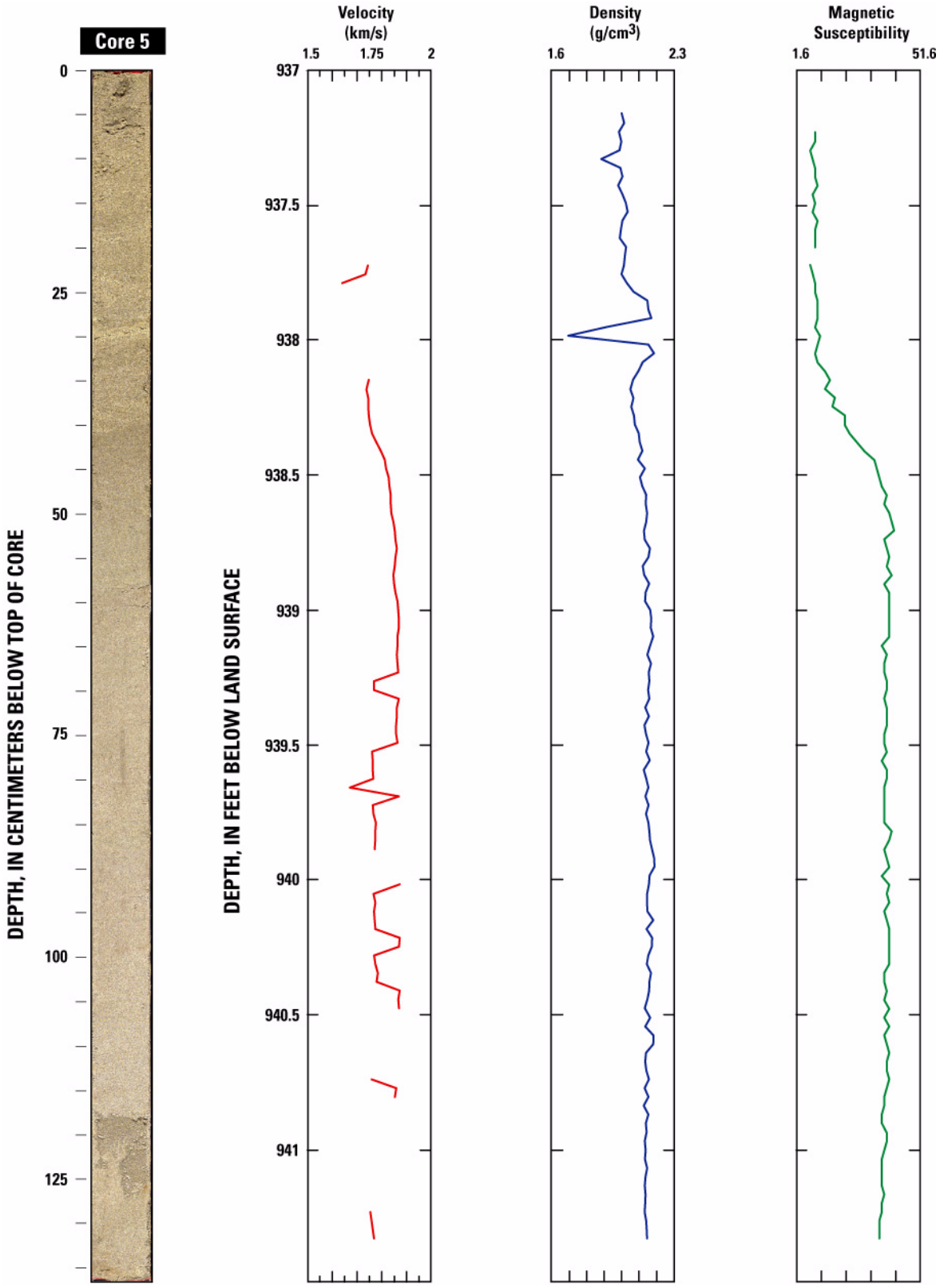

Figure A1.1. Core 5 description.

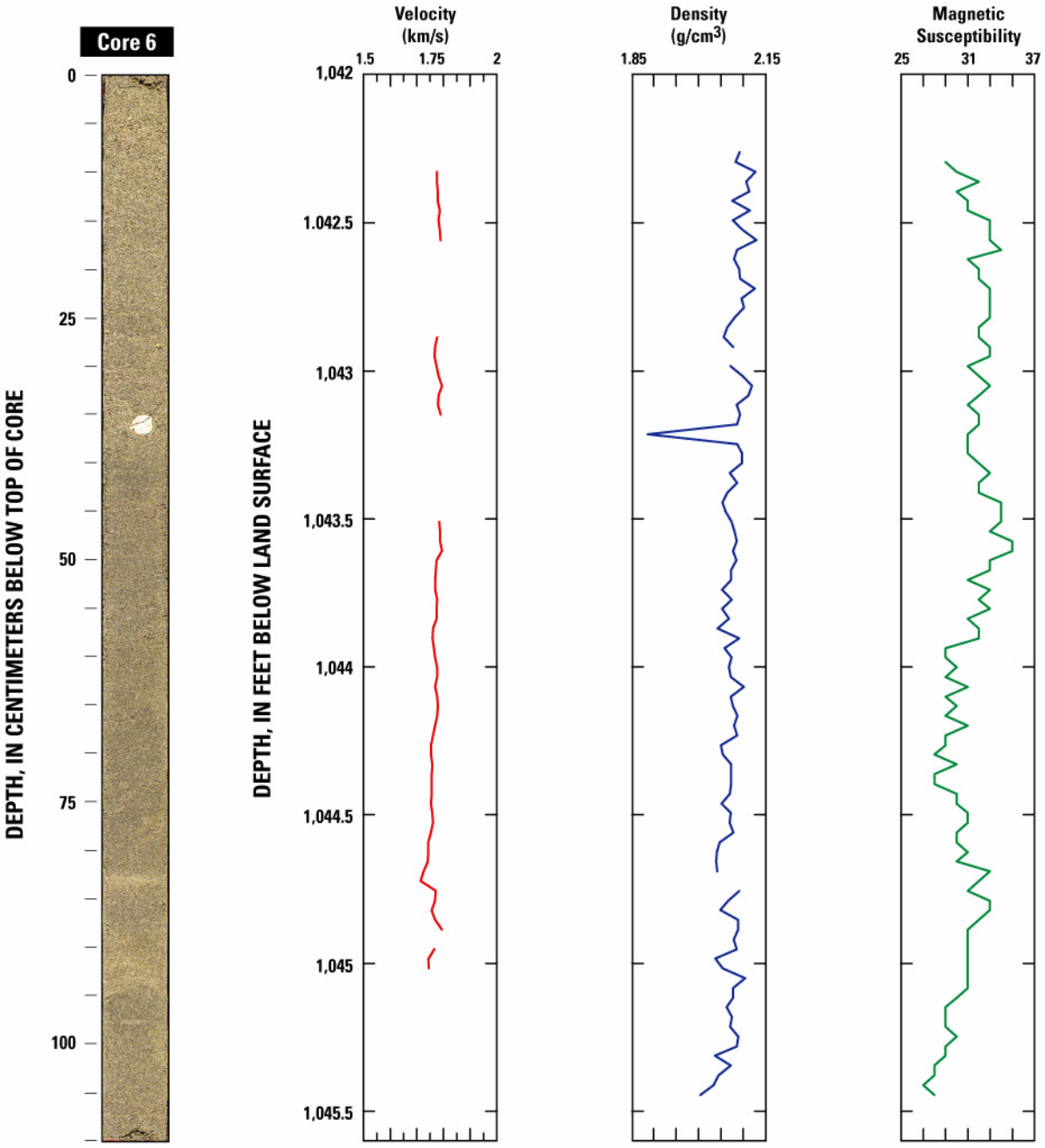

Figure A1.1. Core 6 description.

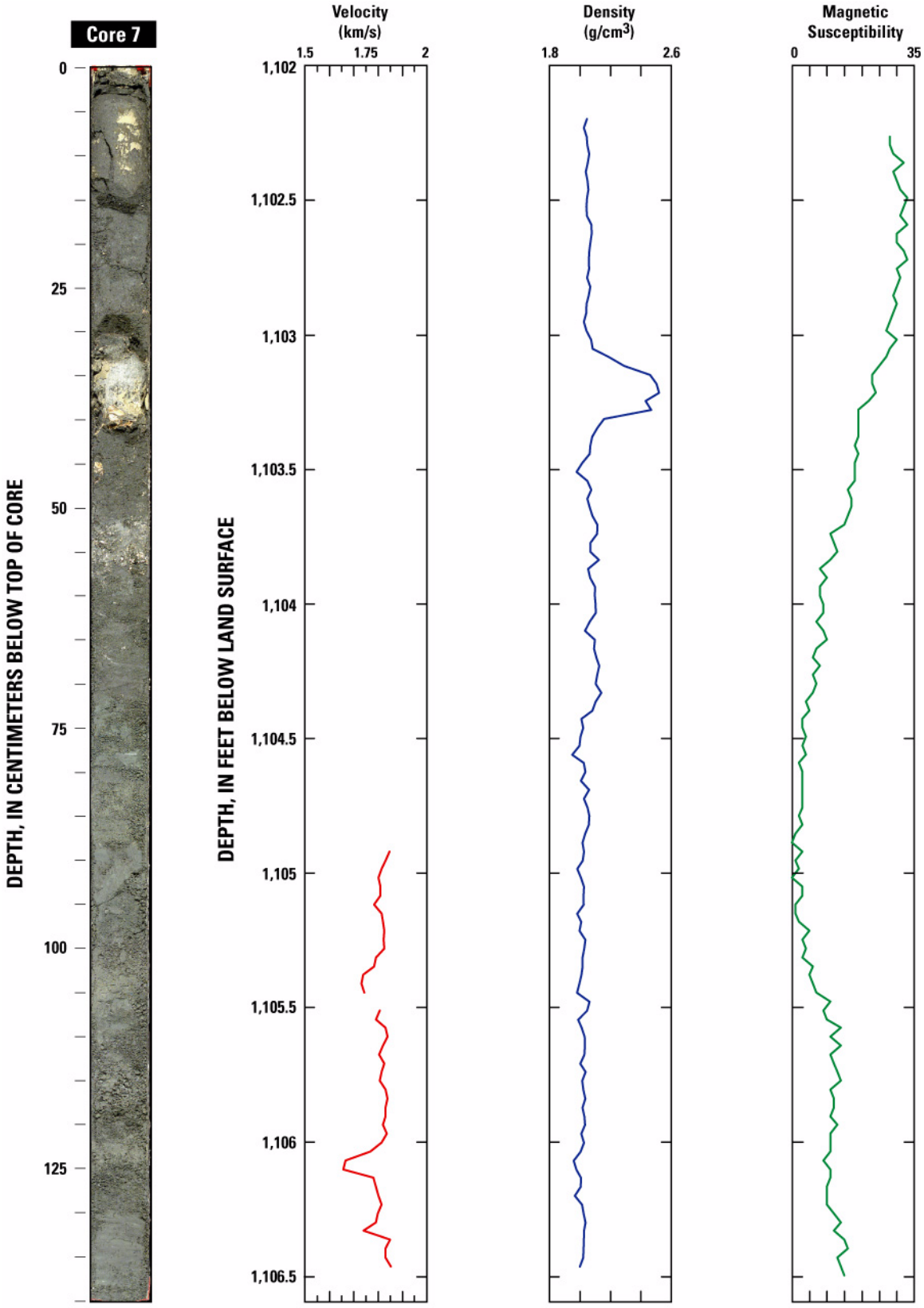

Figure A1.1. Core 7 description.

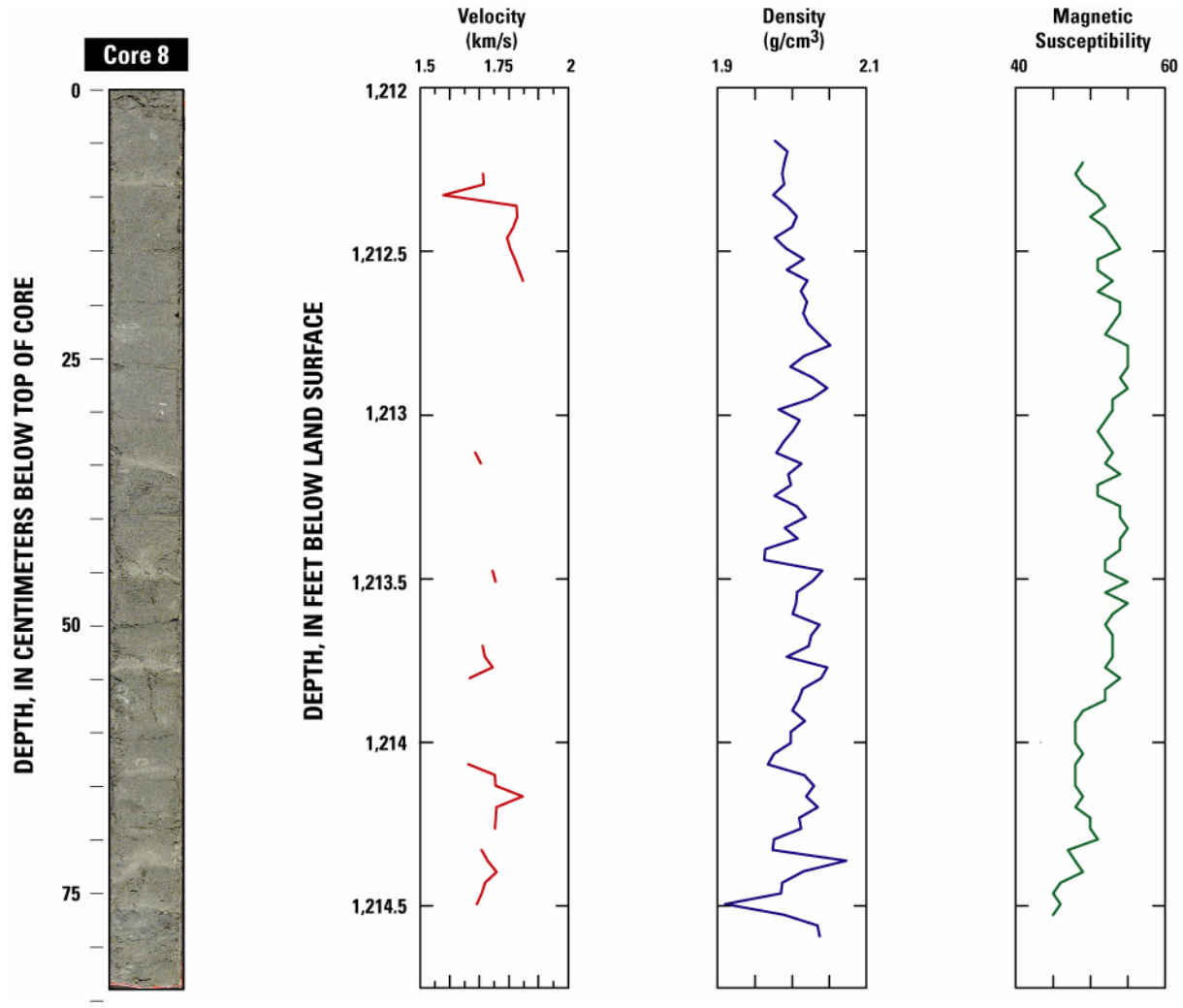

Figure A1.1. Core 8 description.

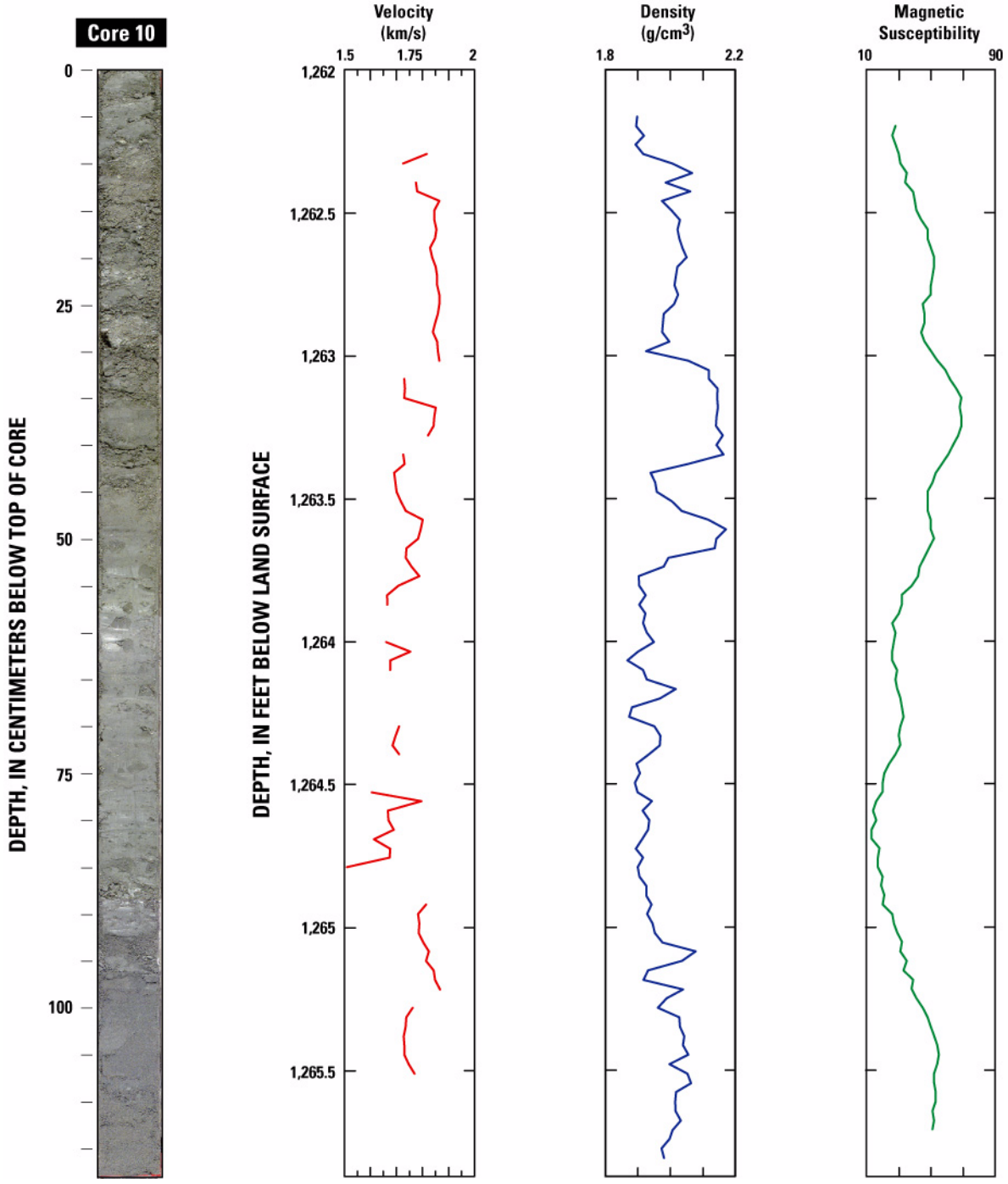

Figure A1.1. Core 10 description.

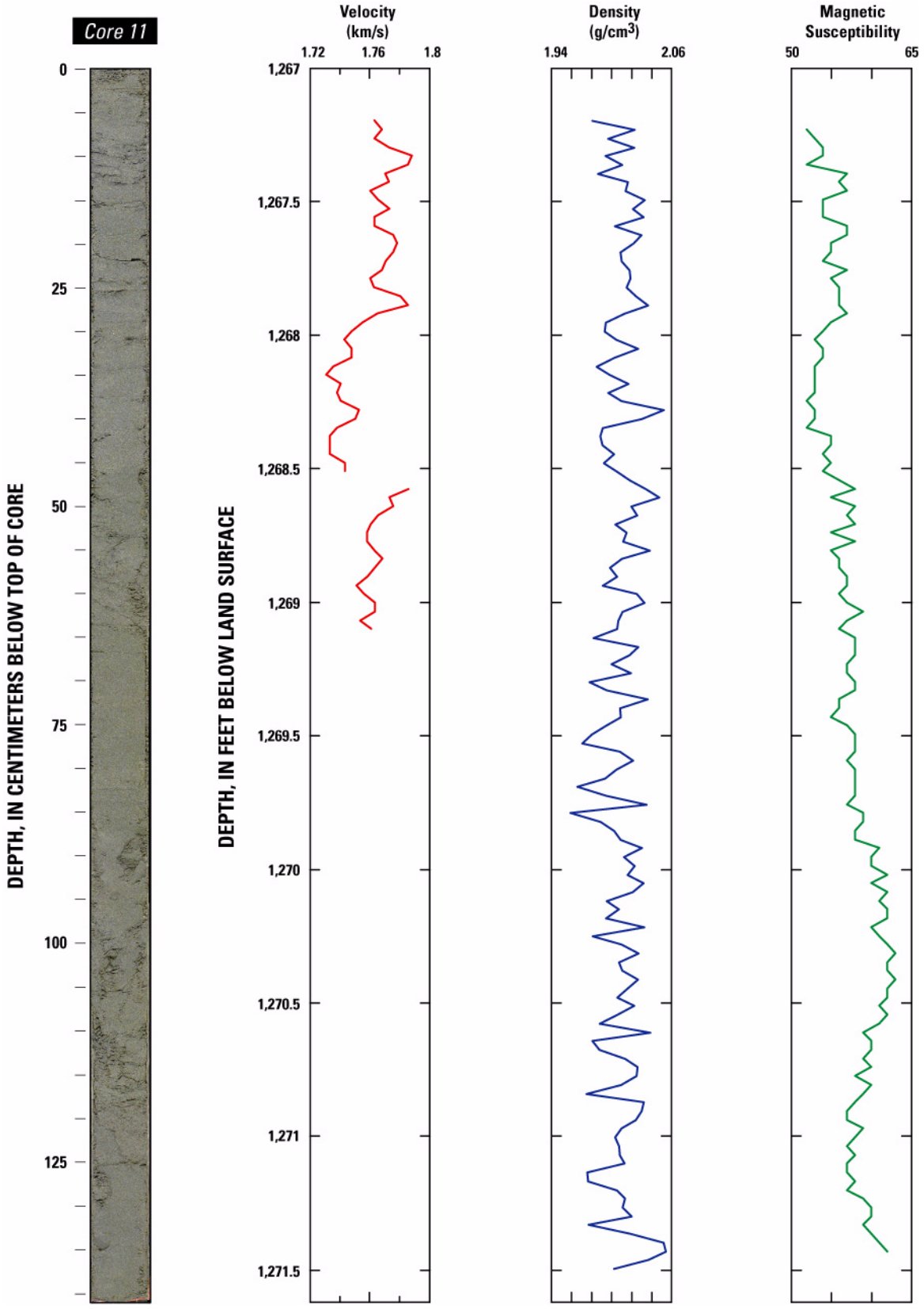

Figure A1.1. Core 11 description.

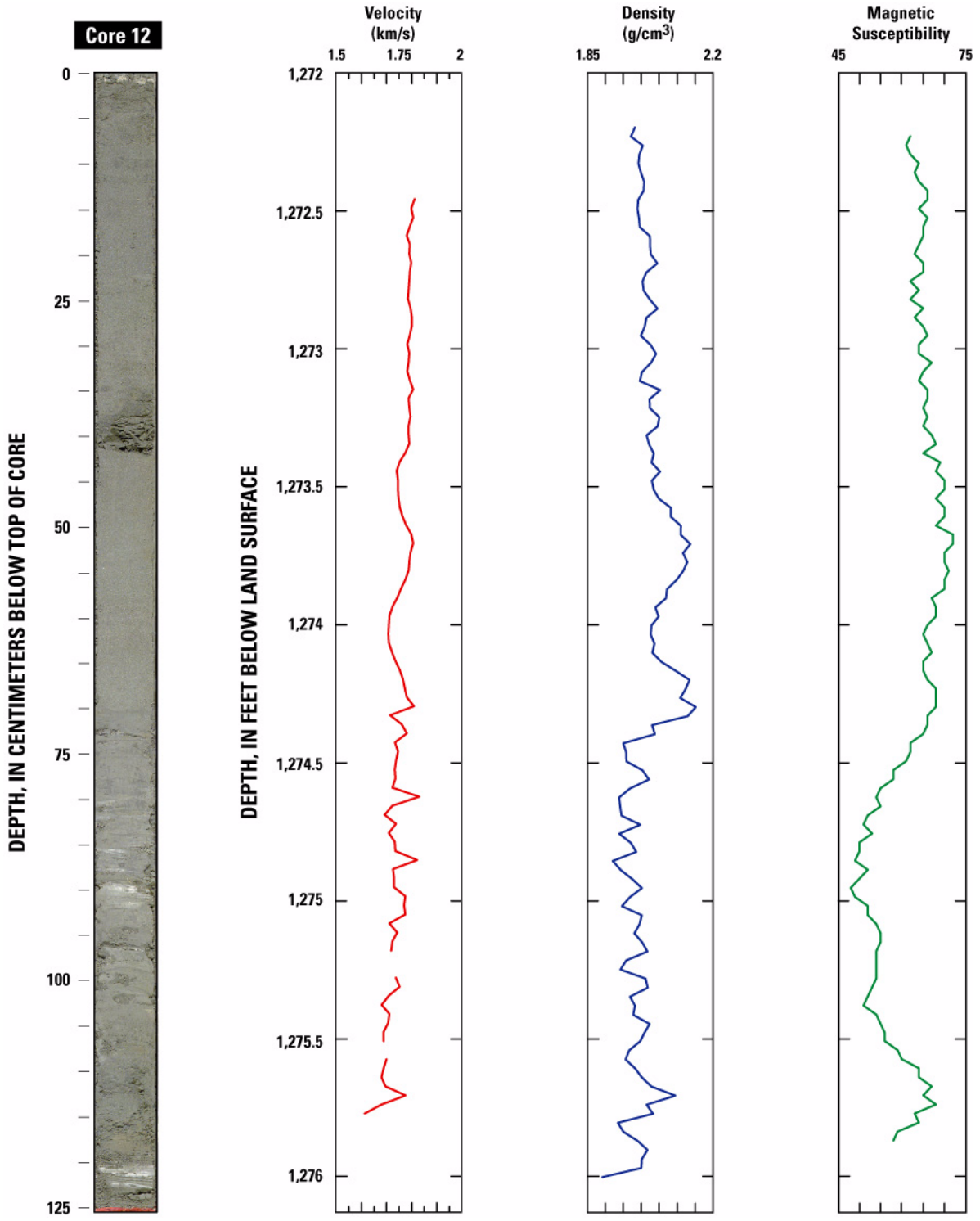

Figure A1.1. Core 12 description.

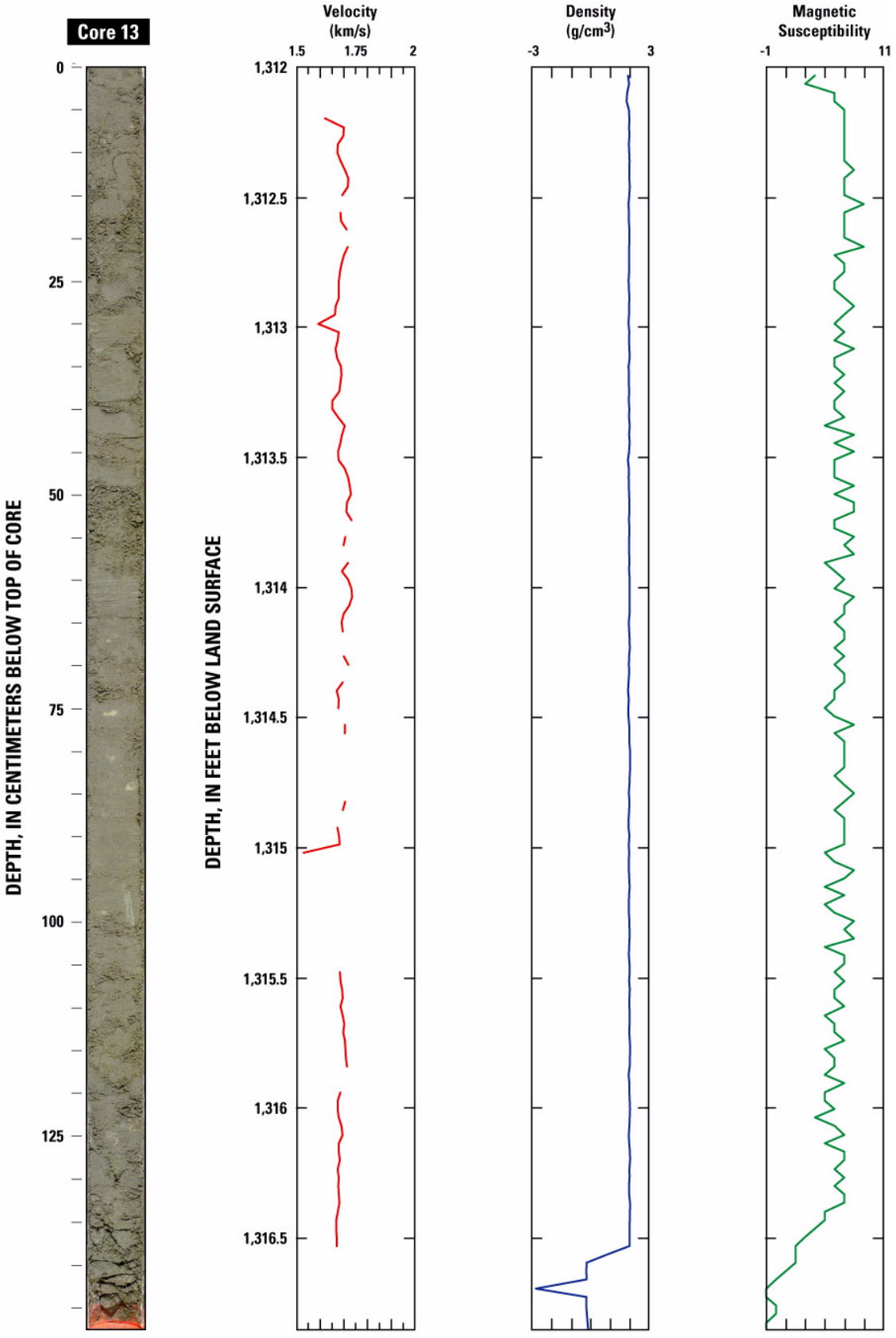

Figure A1.1. Core 13 description.

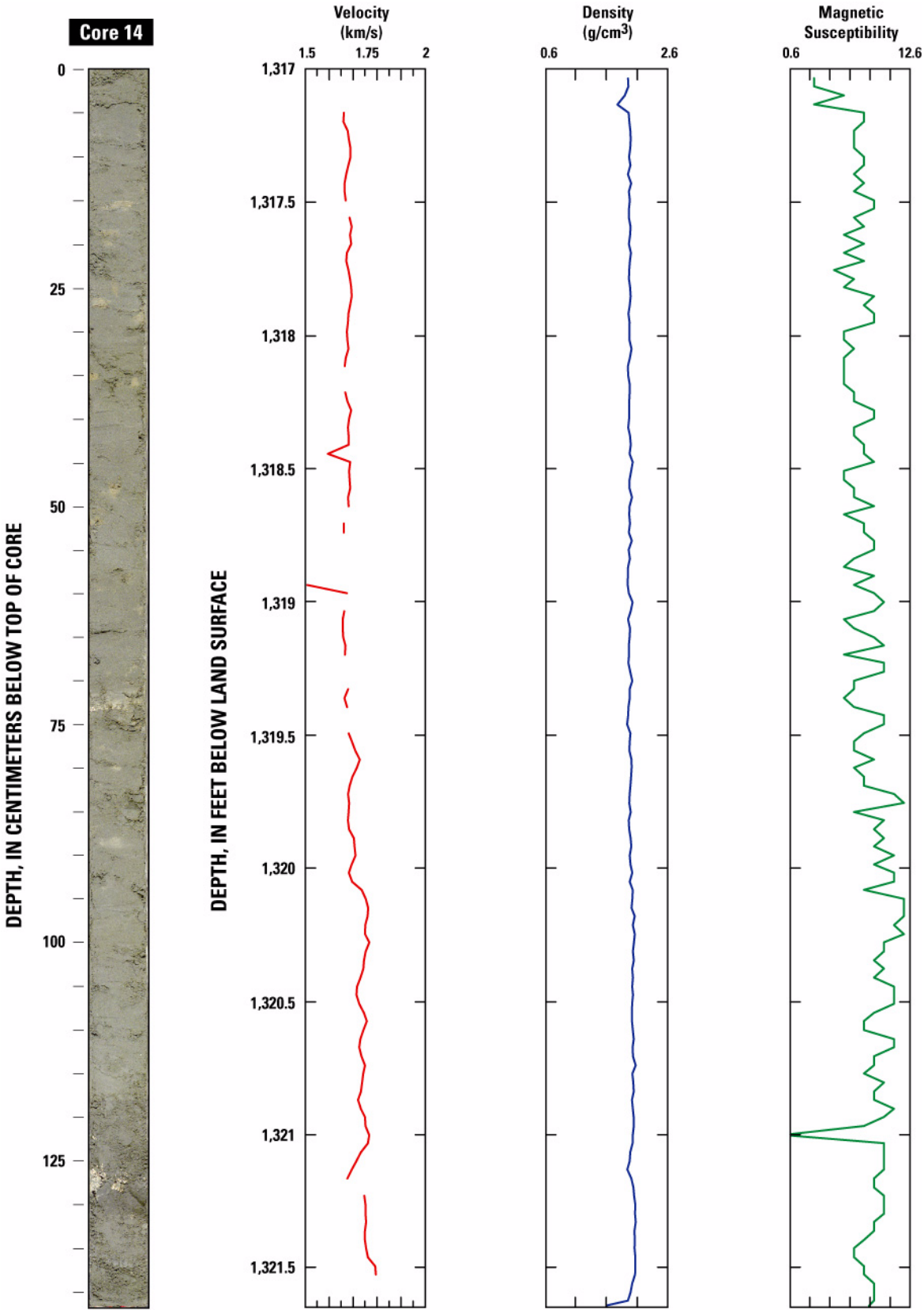

Figure A1.1. Core 14 description.

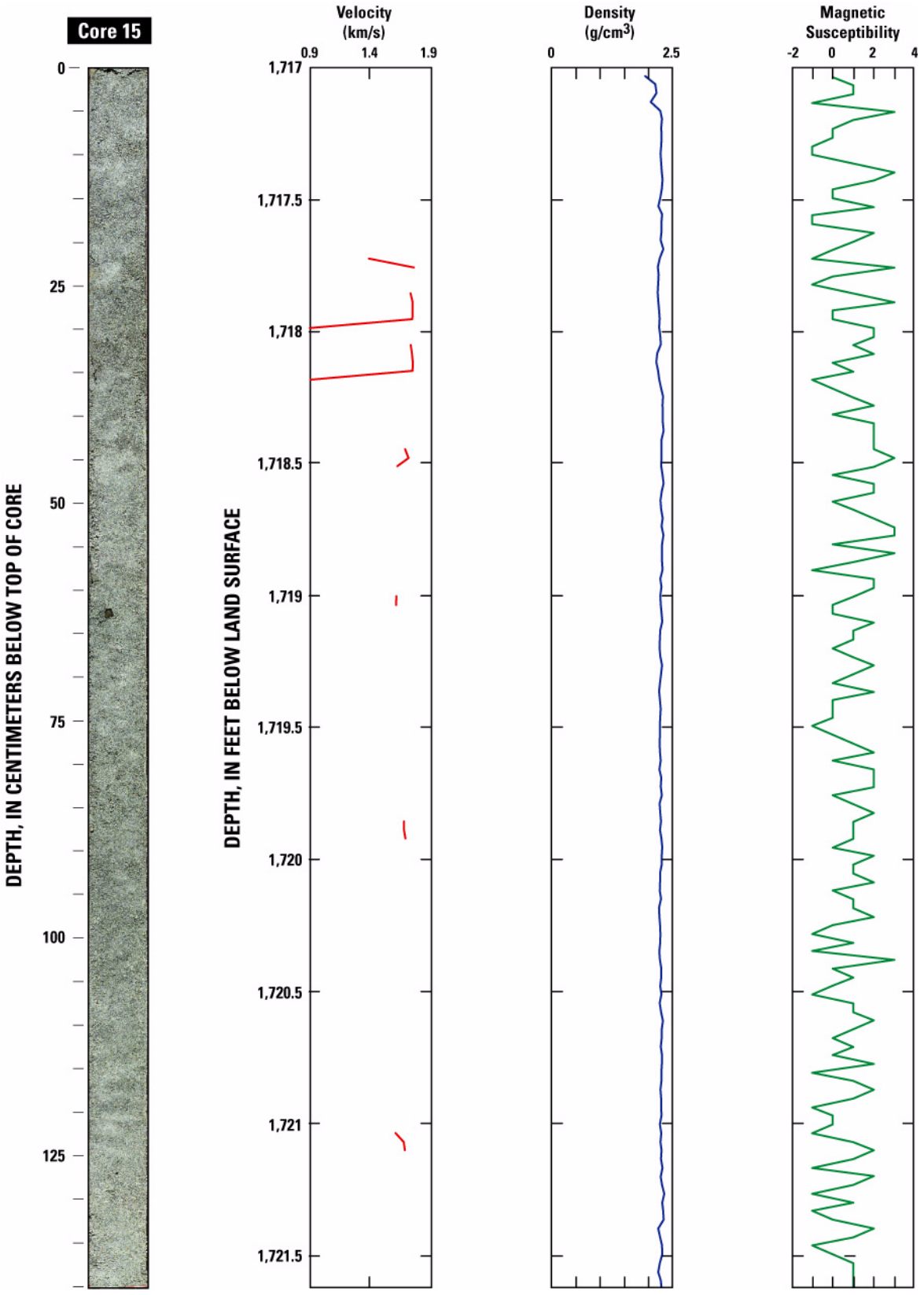

Figure A1.1. Core 15 description.

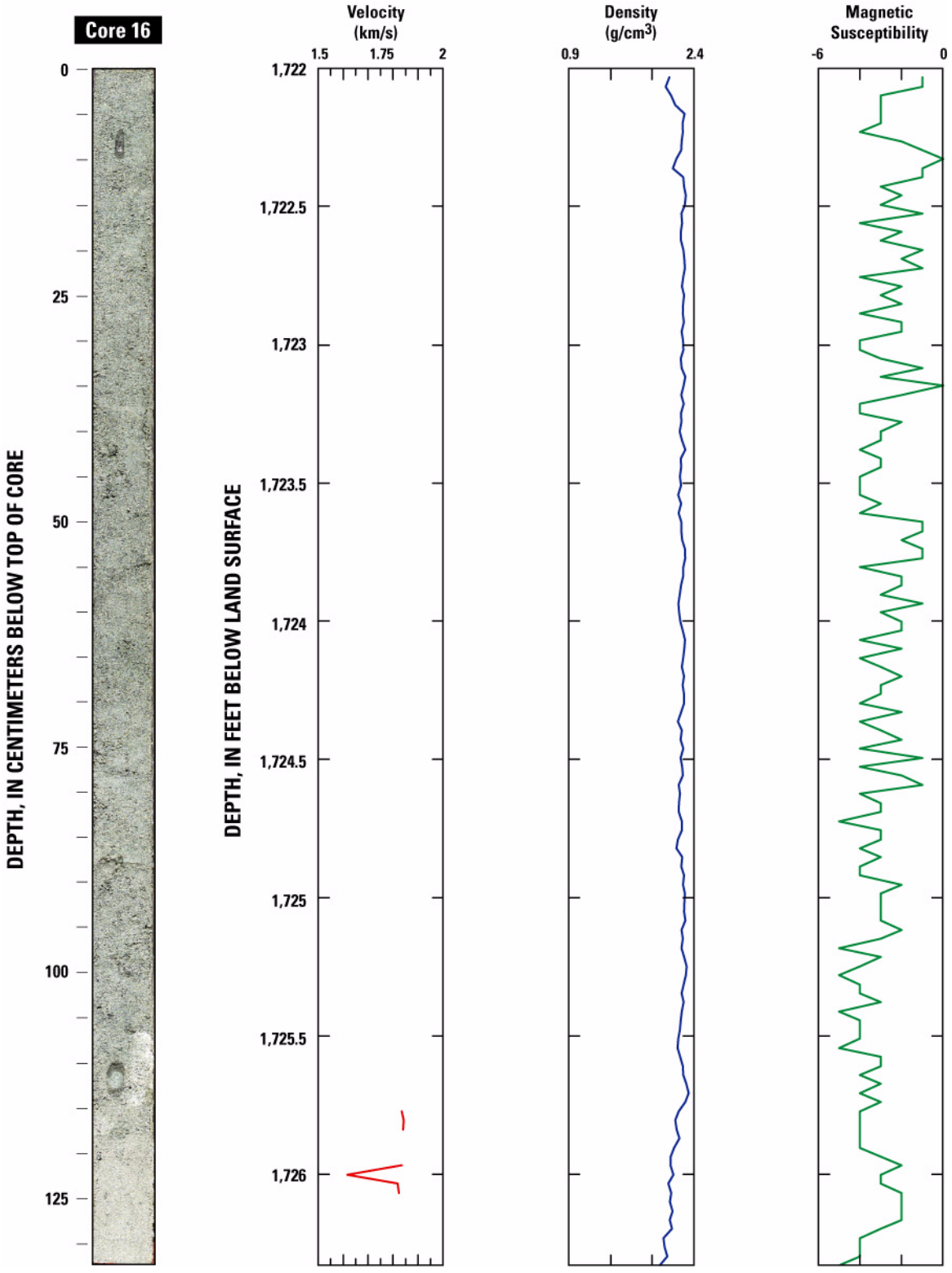

Figure A1.1. Core 16 description.

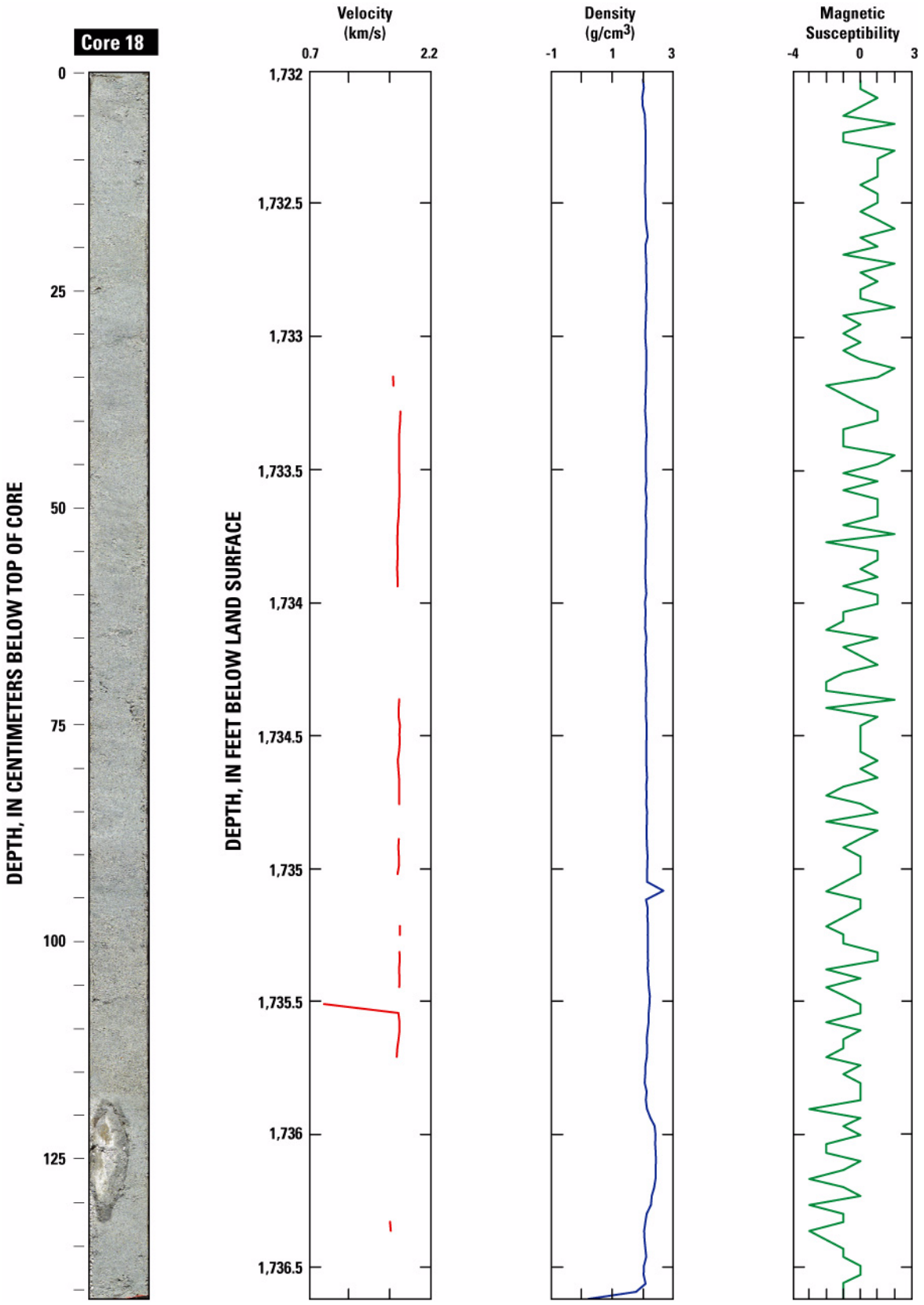

Figure A1.1. Core 18 description.

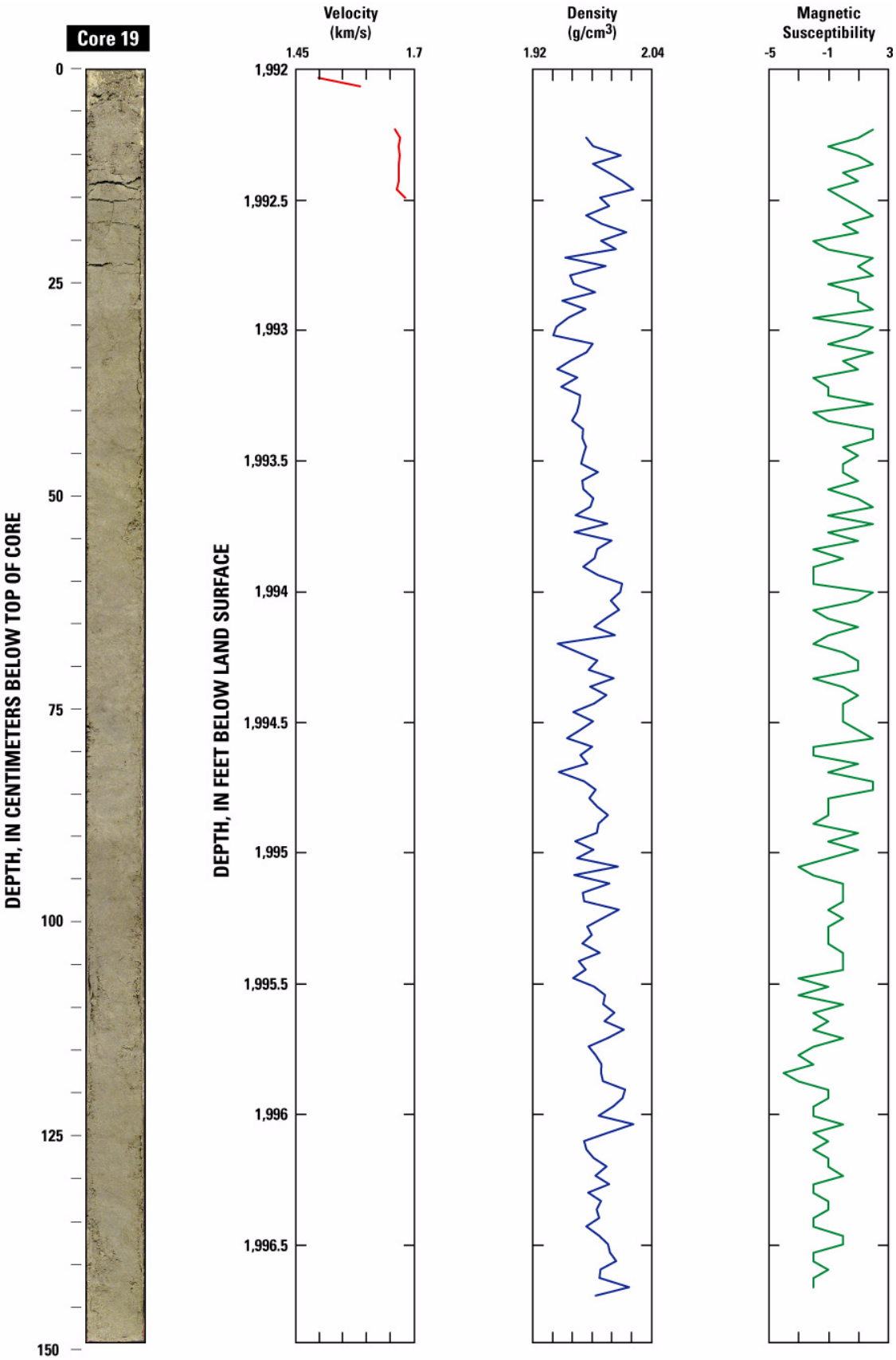

Figure A1.1. Core 19 description.

APPENDIX 2: PALEONTOLOGIC ANALYSES FOR THE DMW1 MONITORING SITE

The analyses of micro-fossils from core and cuttings samples were provided by Kristin McDougall (USGS, Geologic Division) and the analyses for mega-fossils from core samples were provided by Charles Powell (USGS, Geologic Division). The following summarizes the identification of the micro-fossil and mega-fossil samples.

Micro-Fossil Analysis

FORM 9-1861
(JULY 1986)

U.S. DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
REPORT ON REFERRED FOSSILS

Stratigraphic Range Pliocene	**Shipment Number** WWRD-00-1
General Locality (state, country, ocean, etc.) California	**Number of Samples** 13
Quadrangle or Area USGS Marina 7.5-minute Quadrangle	**Region (county, province, sea, etc.)** Monterey County
Fossil Type(s) Foraminifers	**Referred By** R. T. Hanson, Water Resources Division
Formation Purisima Formation (?)	**Report By** Kristin McDougall
Latitude: 36° 41' 57" N **Longitude:** 121° 48' 27" W	**Report Date** Jan. 30, 2001

Project: WRD Project 470656400; R.T. Hanson, Project Chief

Core and cuttings samples were submitted from the Marina Well (DMW1) for foraminiferal analysis. This well is located in Marina State Park, Marina, Monterey County, California. Latitude: 36° 41' 57" N; Longitude: 121° 48' 27" W (fig. 1)

Mf10316 (Field number DMW-1 Core 1, 34–35 cm, depth = approximately 823.12–823.15 feet)
No micro-fossils were observed in this sample.

Mf10317 (Field number DMW-1 Core 1, 65 cm, depth = approximately 824.13 feet)
No micro-fossils were observed in this sample.

Mf10318 (Field number DMW-1 Core 7, 127–128 cm, depth = 1,106.17–1,106.38 feet)
Benthic foraminifers
Bolivina advena striatella (Cushman) - probably reworked
Bolivina cf. *B. decussata* (Brady)
Bolivina californica (Cushman)- probably reworked
Bolivina foraminata (Stewart and Stewart)
Bolivina interjuncta (Galloway and Wissler)
Bolivina marginata (Cushman)
Bolivina vaughani (Natland)
Buccella frigida (Cushman)
Elphidiella hannai (Cushman and Grant)
Elphidium hughesi (Cushman and Grant)
Nonionella cushmani (Stewart and Stewart)
Nonionella miocenica (Cushman)
Uvigerina juncea (Cushman and Todd)
Valvulineria cf. *V. californica* (Cushman)—juveniles, probably reworked

Mf10319 (Field number DMW-1 Core 10, 17–18 cm, depth = 1,262.56–1,262.59 feet)
Benthic foraminifers

Mf10320 (Field number DMW-1 Core 10, 73–74 cm, depth = 1,264.40–1,264.43 feet)
No micro-fossils were observed in this sample.

Mf10321 (Field number DMW-1 Core 12, 86–89 cm, depth = 1,274.82–1,274.92 feet)
Benthic foraminifers
Elphidiella hannai (Cushman and Grant)
Mega-fossil fragments
Fish debris

Mf10322 (Field number DMW-1 Shaker-Cuttings No. 1, 1,225–1,230 feet)
Benthic foraminifers
Buccella frigida (Cushman)
Elpidiella hannai (Cushman and Grant)
Elphidium hughesi (Cushman and Grant)
Nonionella cushmani (Stewart and Stewart)
Nonionella miocenica (Cushman)
Vavulineria californica (Cushman) - juveniles

Mf10323 (Field number DMW-1 Shaker-Cuttings No. 2, 1,365–1,370 feet)
Benthic foraminifers
Buccella frigida (Cushman)
Elphidium hughesi (Cushman and Grant)
Elphidiella hannai (Cushman and Grant)
Nonionella cushmani (Stewart and Stewart)
Nonionella miocenica (Cushman)

Mf10324 (Field number DMW-1 Shaker-Cuttings No. 3, 1,410–1,420 feet)
Benthic foraminifers
Elphidiella hannai (Cushman and Grant)
Elphidium hughesi (Cushman and Grant)
Nonionella cushmani (Stewart and Stewart)

Mf10325 (Field number DMW-1 Shaker-Cuttings No. 4, 1,640–1,660 feet)
Benthic foraminifers
Elphidium hughesi (Cushman and Grant)

Mf10326 (Field number DMW-1 Shaker-Cuttings No. 5, 1,900 feet)
No micro-fossils were observed in this sample.

Mf10327 (Field number DMW-1 Shaker-Cuttings No. 6, 1,940 feet)
No micro-fossils were observed in this sample.

Mf10328 (Field number DMW-1 Shaker-Cuttings No. 7, 1,960–1,980 feet)
No micro-fossils were observed in this sample.

Age: Pliocene

Benthic foraminifers are present in the Marina Well in a core sample at 1,151.99–1,152.38 and 1,305–1,306.24 feet below land surface and in shaker samples from 1,225–1,230 to 1,640–1,660 feet below land surface. Micro-fossils in this 508-foot sequence are Pliocene in age. The Pliocene age is based on the presence of *Elphidium hughesi* and *Nonionella cushmani*, which are characteristic of the Purisima Formation and are not commonly found in the younger Quaternary deposits. The abundance and dominance of these species in this section corresponds to the lower part of the middle Purisima Formation (*Elphidiella hannai* zone) as described by Goodwin and Thompson (1954) from the section at Half Moon Bay. Sample Mf 10318 (core 7), which contains *Uvigerina juncea* may represent the youngest part of the middle Purisima Formation (*Uvigerina juncea* zone; Goodwin and Thompson, 1954). Also included in sample Mf10318 are several species, which are probably reworked from the Miocene, probably Monterey Formation such as *Valvulineria californica* and several of the *Bolivina*.

Ecology:

Most of the foraminiferal assemblages in DMW1 indicate deposition occurred at inner neritic depths 0–50 meter based on the presence of *Elphidiella hannai* and *Elphidium hughesi*. In addition, the presence of several species of *Nonionella, Uvigerina juncea*, *Bolivina interjuncta, B. foraminata*, and *Bolivina vaughani* suggests that water depths were probably at the deeper end of this range.

Correlation:

Although the wells previously examined; MacDonald No. 1 (Ingle, 1985), and Marina Wells No. 10 (Ingle, 1985), 11 (Ingle, 1986), and 12 (Ingle, 1989) contain some of the same species and a reworked Miocene, the foraminiferal assemblages in these wells do not contain the key species *Nonionella cushmani* and *Elphidium hughesi* which distinguish the assemblages in the current well and suggest a Pliocene age. The faunas in the previously examined wells appear to be younger—that is, Pleistocene in age.

Micropaleonthology. Lab No.[1]	Mf10318	Mf10322	Mf10321	Mf10323	Mf10324	Mf10325
Depth (feet)	1,151.99–1,152.38	1,225–1,230	1,305.84–1,306.24	1,365–1,370	1,410–1,420	1,640–1,660
Bolivina advena striatella (Cushman)[2]	2					
Bolivina cf. *B. decussata* (Brady)	3					
Bolivina californica (Cushman)[2]	1					
Bolivina foraminata (Stewart and Stewart)	1					
Bolivina interjuncta (Galloway and Wissler)	1					
Bolivina marginata (Cushman)	1					
Bolivina vaughani (Natland)	1					
Buccella frigida(Cushman)	20	3		2		
Elphidiella hannai (Cushman and Grant)	336	16	34	39	3	
Elphidium hughesi (Cushman and Grant)	241	47		48	4	6
Nonionella cushmani (Stewart and Stewart)	5	20		8	3	
Nonionella miocenica (Cushman)	21	8		8		
Uvigerina juncea (Cushman and Todd)	2					
Valvulineria cf. *V. californica* (Cushman) – juveniles[2]	9	1				
Total foraminifers	644	95	34	105	10	6

[1]No micro-fossils were observed in samples Mf10319 and Mf10320.

[2]Probably reworked fossils.

Mega-Fossil Analysis

U.S. Department of the Interior
U.S. Geological Survey
Report on Referred Fossils

Stratigraphic Range: Pliocene to possibly Pleistocene
General Locality: California
Quadrangle: Marina 7.5'
Fossil Type: Mollusks
Formation: Purisima
Latitude: 36˚41'57" N Longitude: 121˚48'27"

Shipment No.:
Number of Samples: 3
Region: Monterey Co.
Referred by: R. T. Hanson
Report by: C. Powell, II
Report date: 12/1/2000

This E&R report fossils mollusks from the Marina Well (DMW1), located in Marina State Park, Marina, Monterey County, California.

Field No.: DMW1 core 7 @ 23–58 cm.
Mollusca
Bivalvia
Clinocardium sp.
Macoma sp.
Gastropoda
Cryptonatica affinis (Gmelin)
Comments: These taxa are found from southern California to Alaska in water depths from the intertidal zone to at least 150 m. They are all living taxa which have fossil records back to the Miocene. They are not age or environmentally significant.

Field No.: DMW1 core 13 @ 127–131 cm.
Mollusca
Bivalvia
Macoma sp.
Comments: This genus is found from southern Chile to northern Alaska in water depths from the intertidal zone to over 1,500 m. It also has a fossil record back to at least the Oligocene. It is not age or environmentally significant.

Field No.: DMW1 core 14 @ 124–134 cm.
Mollusca
Bivalvia
Anadara trilineata (Conrad)
Comments: *Anadara trilineata* (Conrad) is well known from the Miocene to Pliocene from British Columbia south to southern California (Moore, 1983). It has also been reported from the Pleistocene Scotia Bluffs Sandstone (Roth, 1979), but I doubt this age call. This taxon suggest normal marine conditions at shelfal water depths and a late Miocene to late Pliocene age. It is common in the Purisima Formation.

APPENDIX 3: WATER-CHEMISTRY DATA FOR THE DMW1 MONITORING WELLS AND CORE PORE WATERS

The water-chemistry data obtained from sampling and analysis of the monitoring-well samples are reported in table A3.1, and the data collected from pore waters extracted from the wire-line cores retrieved during drilling are presented in table A3.2. Additional water-chemistry data from the nearby water-supply wells for 1995, 1997, and 2000 (C. Moss, Monterey County Water Resources Agency, written commun., 2000) were used for the purposes of comparison with the monitoring-well data. The boron and strontium isotope samples were collected along with the other water-chemistry samples for the DMW1 monitoring wells and analyzed by research geochemists Tom Bullen and John Fitzpatrick of the USGS, Water Resources Division. The additional water-chemistry data from other wells were sampled from joint sampling and analyses of upper-aquifer system wells in the Salinas Valley performed by the USGS and the University of California at Santa Cruz (Vengosh and others, 2002). The average composition of seawater (Hem, 1985) was used for hydrologic and water-chemistry comparisons.

Monitoring-Well Water

The water-chemistry samples from the DMW1 monitoring-site wells were collected under the USGS protocol established for water-chemistry sampling (Wilde and others, 1998). Water-chemistry samples were obtained from the deep-aquifer system monitoring wells with positive-displacement pumps after well development. The water-chemistry data are summarized by groups of constituents that are used for geochemical and hydrologic interpretations. These groups include major anions: dissolved-solids concentration and specific conductance; iron and manganese; other selected trace elements; pH, temperature, and dissolved oxygen; total dissolved carbon; tritium; stable isotopes of deuterium, oxygen, boron, and strontium; and the carbon (C^{-14} and C^{-13}) isotopes.

***Major, Minor, and Trace-Element Chemistry*—** The major, minor and trace element chemistry are used to assess the chemical characteristics of the ground-water samples and help to determine the source and movement of the ground water.

Major anions – Chloride concentrations from monitoring-well samples ranged from 48 to 10,801 mg/L. The most saline samples from the nearby MCWD deep-aquifer system water-supply wells, greater than 100 mg/L of chloride, are from well No. 12 (Geoconsultants, Inc., 1989). Sulfate concentrations from monitoring-well samples ranged from 32 to 1,506 mg/L. Sulfate concentrations in all other samples from monitoring-well site (table A3.1) and MCWD deep-aquifer system water-supply wells (Geoconsultants, Inc., 1983, 1986, 1989) were less than 75 mg/L.

Dissolved-Solids Concentration and Specific Conductance – Dissolved-solids concentrations from monitoring-well samples ranged from 318 to 23,840 mg/L. The specific conductance ranged from 459 µS/cm to 28,900 µS/cm. The highest dissolved-solids and specific conductance values were from the ground-water sample from well DMW1-3. The lowest dissolved-solids concentrations and specific-conductance values were in water from DMW1-2.

Iron and Manganese – Iron and manganese concentrations from monitoring-well samples ranged from less than 10 to 150 µg/L and 7 to 385 µg/L, respectively.

Other Selected Trace Elements – Ground-water samples from deep-aquifer system monitoring-well site DMW1 contained iodide concentrations ranging from 0.07 mg/L in the deepest monitoring well (DMW1-1) to 0.19 mg/L in the shallowest monitoring well (DMW1-4). Barium concentrations ranged from 23 µg/L in well DMW1-2 to 244 µg/L in well DMW1-3. Strontium concentrations ranged from 76 µg/L in well DMW1-2 to 19,827 µg/L in well DMW1-3. Bromide concentrations ranged from less than 0.14 mg/L in well DMW1-2 to 39 mg/L in well DMW1-3. The water samples from the three deeper monitoring wells (DMW1-1, 2, 3) contained arsenic concentrations ranging from 6.4 to 7.3 ug/L.

pH, Temperature, and Dissolved Oxygen— The pH values from deep-aquifer system monitoring-well samples are generally basic values, ranging from 7.1 to 8.5 for DMW1 water samples (table A3.1) and from 8.0 to 8.5 for water-supply well samples (Geoconsultants, Inc., 1983, 1986, 1989). The temperature of the water samples from the monitoring wells ranged from 21° to 26° Celsius (C). Temperatures as great as 36° C at 1,750 ft bls were measured with a wireline temperature probe during geophysical logging in the deep-aquifer system monitoring-well site and also were measured in several of the nearby MCWD deep-aquifer system water-supply wells (Geoconsultants, Inc., 1993). The dissolved-oxygen concentration measured in ground-water samples from the four deep-aquifer system monitoring wells ranged from 0.0 to 0.4 mg/L (table A3.1).

Total Dissolved Carbon – The concentration of total dissolved organic carbon for the DMW1 wells ranged from less than 0.33 to 0.88 mg/L carbon and was greatest in the sample from the shallowest well (DMW1-4) (table A3.1).

Stable Isotopes – Stable isotopes of oxygen and hydrogen (deuterium) are used to help determine the source of water, isotopes of boron help to identify the source of dissolved ions that contribute to poor-quality water, and isotopes of strontium help to infer the source of the sediments that the water flows through.

Oxygen-18 and deuterium are naturally occurring stable isotopes of oxygen and hydrogen. Oxygen-18 (^{18}O) and deuterium (D) abundances are expressed as ratios in delta notation as per mil (parts per thousand) differences relative to the standard known as Vienna Standard Mean Ocean Water (VSMOW) (Gonfiantini, 1978). Because the source of most of the world's precipitation is the evaporation of seawater, the delta-^{18}O and delta-D composition of precipitation throughout the world is linearly correlated. This relation is known as the meteoric water line (Craig, 1961). The delta^{-18}O and delta-D composition of ground water relative to the meteoric water line and relative to the isotopic composition of water from other sources is an indicator of the source and movement of ground water. The delta-^{18}O and delta-D composition of water from monitoring wells ranged from –7.8 to –4.76 per mil and –32.5 to 54.6 per mil, respectively (table A3.1).

Boron-10 and -11 are naturally occurring stable isotopes of boron. Natural and anthropogenic processes fractionate the boron-11 content relative to boron-10. The abundance of boron-11 (^{11}B) is expressed in delta notation (del) as per mil (parts per thousand) differences relative to the standard reference boron isotopic ratio of boron-11 to boron-10 of 4.161 for National Bureau of Standards boric acid sample No. 951 (Tom Bullen, U.S. Geological Survey, written commun., 2001). Ground-water samples from the deep-aquifer system monitoring wells ranged in delta-boron-11 content from 7.7 to 26.7 per mil (table A3.1, fig. 13B).

Strontium-87/86 isotopes are naturally occurring stable isotopes of strontium and are expressed as a ratio (Faure and Powell, 1972). Strontium from ground-water samples undergoes cation exchange between calcium and strontium from the surrounding sediments. This exchange process is relatively rapid for most ground-water flow rates and results in a strontium isotopic composition of ground water that reflects the isotopic composition of the aquifer sediments. Therefore, strontium isotopes are a useful indicator of the source of the sediments that compose the aquifer. Strontium isotopes also can be affected by base-ion exchange during seawater intrusion, but this effect may be too localized to be discernable from sampling of ground water on a regional scale. The strontium isotopes of ground-water samples from deep-aquifer system monitoring wells ranged in strontium-87/86 ratio content from 0.70732 to 0.70841 (table A3.1, fig. 13A).

Unstable Isotopes–Unstable isotopes of water and carbon are used to identify the potential age of ground-water samples.

Tritium—Tritium (H^3) is a naturally occurring radioactive isotope of hydrogen having a half-life of 12.4 years. The activity of tritium is measured in pico curies per liter (pCi/L); and 1 pCi/L is equivalent to about 2.2 disintegrations of tritium per minute or about one tritium atom in 3.1×10^{17} atoms of hydrogen. Prior to 1952, the tritium concentration of precipitation in coastal California was about 6.5 pCi/L (Izbicki, 1996). Beginning in 1952, about 800 kilograms (1,760 pounds) of tritium was released as a result of the atmospheric testing of nuclear weapons (Michel, 1976), and the tritium activity of precipitation at Santa Maria, California, increased to more than 2,200 pCi/L (International Atomic Energy Agency, 1981). This release stopped in 1962 with the signing of treaties banning the atmospheric testing of nuclear weapons. Since that time, tritium activity in precipitation has decreased to pre-1952 levels. Because tritium can be part of the water molecule and tritium activities are not significantly affected by reactions other than radioactive decay, it is an excellent tracer of the movement of water

and relative age of water on time scales ranging from 0 to 50 years before present (Izbicki and others, 1993). No tritium was detected in samples from the deep-aquifer system monitoring wells (table A3.1). No tritium data are available from the deep-aquifer system water-supply wells.

Carbon Isotopes—Carbon-14 (^{14}C) is a naturally occurring radioactive isotope of carbon that has a half-life of about 5,730 years. Carbon-14 data are expressed as percentage modern carbon (pmc) by comparing carbon-14 activities with the specific activity of National Bureau of Standards oxalic acid: 12.88 disintegrations per minute per gram of carbon in the year 1950 equals 100 percent modern carbon. In addition to the naturally occurring carbon-14, carbon-14 also was produced during the atmospheric testing of nuclear weapons. As a result, carbon-14 activities can exceed 100 percent modern carbon. Carbon-14 is a tracer of the movement and relative age of water on time scales ranging from several hundred to more than 30,000 years before present. Because carbon-14 is not part of the water molecule, carbon-14 activities are affected by chemical reactions between dissolved constituents and aquifer material. As a result, carbon-14 data must be corrected using chemical, mineralogical, and carbon-13 data to evaluate chemical reactions that occur within an aquifer and to estimate the actual age of a water sample. Davis and Bentley (1982) estimated that errors in carbon-14 ages may be as much as 100 percent. The carbon-14 ages were adjusted in this study on the basis of the percentage of carbon-14 for initial waters. The carbon-14 content of ground-water samples of shallow aquifers from the Pajaro Valley were used from well (11S/3E-24D3M) with a carbon-14 content of 88 percent and tritium present. These samples represent a relatively recently recharged ground water. The percent of modern carbon-14 is increased by the resulting ratio of carbon-14 values to the 88 percent for the initial water of recent aquifer recharge. The values for uncorrected percent modern carbon were measured to be 4.0 pmc in DMW1-1 and 6.5 pmc in DMW1-2 (table A3.1).

Carbon-13 is a stable isotope of carbon. Carbon-13 data are expressed as ratios in delta notation as per mil differences relative to the ratio of carbon-13 to the more common isotope carbon-12 in standard Peedee Belemnite (PDB) (Gonfiantini, 1978). The delta-carbon-13 values for the deep-aquifer system monitoring wells at DMW1 ranged from –10.99 per mil to –11.11 per mil (table A3.1). Along with the presence of hydrogen sulfide noted during sampling of the DMW1 monitoring wells, this may indicate that the deeper wells are in a zone where reducing conditions and methanogenesis is occurring.

Pore Water

Pore-water samples were collected from most cores. Multiple samples at 6-inch intervals were taken from similar sediments within each core. These subsamples were combined and squeezed under pressure to extract the pore fluids. Chemical results from pore fluids can be compromised by drilling fluids when the sediments are relatively coarse grained. Because most of the samples from DMW1 cores are clay to fine sand, this is probably not an issue. The results of anion and selected isotope analyses for the pore-water samples are given in table A3.2.

Pore-water samples contained from 90 to 2,000 mg/L sulfate and 64 to 9,800 mg/L chloride (table A3.2). The pH values from all pore-water samples are generally basic, with values ranging from 7.8 to 9.8 (table A3.2). The Eh values from the pore waters ranged from 10 to 232 millivolts and generally represent reduced conditions.

Selected pore-water samples were also analyzed for deuterium and oxygen isotopes (table A3.2). The delta-oxygen-18 and the delta-deuterium values ranged from –4.62 to –6.94 per mil and from –33.08 to –54.0 per mil, respectively. These data generally plot below the meteoric water line (fig. 12). The squeezing process may cause mechanical fractionation of the oxygen isotopes. The offset of oxygen isotope values from the pore fluid samples from the DMW1 cores compared with the well samples may be the result of this fractionation process (fig. 13).

Table A3.1. Summary of water-chemistry data for the deep-aquifer monitoring-well site DMW1, Marina, California

Attribute	Units	State well number			
		14S/1E-24L5	14S/1E-24L4	14S/1E-24L3	14S/1E-24L2
Local well name		DMW1-4	DMW1-3	DMW1-2	DMW1-1
Station number		364157121482704	364157121482703	364157121482702	364157121482701
Sample type	Collection method	Pumped	Pumped	Pumped	Pumped
Depth of well	Feet	970	1,080	1,430	1,880
Depth of screened interval	Feet	930–950	1,040–1,060	1,410–1,430	1,820–1,860
Sample	Date	6/23/2000	6/24/2000	6/23/2000	6/25/2000
Sample	Time	1930	1730	2245	1945
Specific conductance, field	µS/cm @ 25C	661	28,900	456	868
Specific conductance, lab	µS/cm	672	28,500	459	881
pH, field	Standard	7.82	7.07	8.46	8.31
pH, lab	Standard	7.87	6.86	7.78	7.92
Temperature, water	Degrees C	21	22.5	21.5	26
Temperature, air	Degrees C	14	16.5	14	16.5
Oxygen, dissolved	mg/L	.2	.2	.4	0
Calcium, dissolved	mg/L	31.8	2,570	7.71	15.3
Magnesium, dissolved	mg/L	11.1	1,080	2.74	1.90
Sodium, dissolved	mg/L	94.0	2,770	81.1	164
Potassium, dissolved	mg/L	3.0	31.9	5.2	3.8
Alkalinity	mg/L	160	47	110	120
Alkalinity	mg/L as $CaCO_3$	156	57	114	115
Sulfate, dissolved	mg/L	61.5	1,510	32.0	74.0
Chloride, dissolved	mg/L	68.6	10,800	47.8	153
Fluoride, dissolved	mg/L	.2	.2	.1	.2
Bromide, dissolved	mg/L	.17	39.1	.14	.56
Iodide, dissolved	mg/L	.186	.159	.019	.065
Silica, dissolved	mg/L	45.8	29.4	64.4	23.9
Solids, residue at 180°C	mg/L	417	23,800	318	506
Nitrogen, nitrite, dissolved	mg/L as N	<.010	<.010	<.010	<.010
Nitrogen, NO_2 + NO_3, dissolved	mg/L as N	<.050	<.050	<.050	<.050
Nitrogen, ammonia, dissolved	mg/L as N	<.020	.722	.471	.557
Nitrogen, ammonia + organic, dissolved	mg/L as N	<.10	<.10	.50	.57
Phosphorous, dissolved	mg/L as P	.199	.063	.115	<.050
Phosphate, ortho, dissolved	mg/L as P	.184	.069	.113	.014
Aluminum	µg/L	<15	<225	E10	E9
Barium, dissolved	µg/L	57	244	23	47
Boron, dissolved	µg/L	145	252	94	108
Iron, dissolved	µg/L	<10	<150	<10	<10
Arsenic	µg/L	6.8	7.3	6.4	<2.0
Lithium	µg/L	40.8	406	32.9	35.0
Manganese, dissolved	µg/L	20.512	384.77	7.1839	11.876
Strontium, dissolved	µg/L	353	19,800	76.3	387
Delta-deuterium	Per mil	-54.6	-32.5	-48	–51.6
Delta oxygen-18	Per mil	-7.8	-4.76	-7.12	–7.36
Tritium	pCi/L	.4	<0.3	<0.3	<0.3
Tritium, prec. est.	pCi/L	.58	.64	.64	.64
Carbon-13/12	Per mil	-10.99	-11.11	-13.32	–11.11
Carbon-14	Percent modern carbon	2.110	2.840	6.530	4.040
Strontium-87/86	Ratio	.70841	.70732	.70855	.70805
Delta-boron-11	Per mil	11.00	7.70	26.70	21.70

Table 3.2. Summary of water chemistry for pore-water extractions from cores for the deep-aquifer monitoring-well site, Marina, California.

[—, no data]

Drill site core number	Sample depth, feet below land surface	Percent Salt grams (NaCl per 100 grams water)	Percent seawater (as chloride)	pH, lab (standard units)	Reduction-oxidation potential (millivolts as Eh)	N-NO_2 (mg/L as N)	N-NO_3 (mg/L as N)	Chloride, dissolved (mg/L)	Bromide, dissolved (mg/L)	Phospho-rus, ortho (mg/L as P)	Sulfate, dissolved (mg/L as $SO_{4)}$	O^{18}/O^{16} (ratio per mil)	H^{2}/H^{1} (ratio per mil)
CDMW1- 1	822–827	0.08	2	—	—	0.10	<0.04	305	<1.2	<1.2	200	–6.94	–54.0
CDMW1- 2a	922–927	.05	1	—	—	<.08	.77	127	<1.2	<1.2	200	–6.7	–52.27
CDMW1- 2b	922–927	.10	2	—	—	.09	—	300	<1.2	<1.2	505	—	—
CDMW1- 3	927–932	.05	1	7.8	160	<.04	.22	115	<.6	<.6	185	—	—
CDMW1- 4	932–937	.05	1	8.2	200	<.04	2.6	114	<.6	<.6	185	—	—
CDMW1- 5	937–942	.05	1	8.1	232	<.04	2.1	123	<.6	<.6	190	–6.92	–52.61
CDMW1- 6	1,042–1,047	.27	7	—	—	<.2	<.2	1,300	3.2	<3	700	–5.25	–38.6
CDMW1- 7	1,102–1,107	1.55	52	8.5	—	<2	<2	9,800	<30	<30	1,500	–4.62	–33.08
CDMW1- 7	1,102–1,107	1.55	52	—	—	<20	<20	9,800	<300	<300	2,000	—	—
CDMW1- 8	1,212–1,217	.07	1	8.9	62	.03	.19	170	<.3	<.3	285	–6.49	–43.78
CDMW1- 8	1,212–1,217	.07	1	—	—	<.04	.16	170	.6	<.6	280	—	—
CDMW1- 8	1,212–1,217	.07	1	—	—	.02	.27	175	.3	<.3	290	—	—
CDMW1- 8	1,212–1,217	.07	1	—	—	.02	.22	185	.4	<.3	310	—	—
CDMW1- 10b	1,262–1,267	.05	<1	9.7		<.04	.60	81	<.6	<.6	145	—	—
CDMW1- 11	1,267–1,272	.06	<1	9.8	10	.06	.04	98	<.6	<.6	205	—	—
CDMW1- 12	1,272–1,277	.06	1	—	—	.13	.82	122	<1.2	<1.2	200	–6.2	–44.51
CDMW1- 13	1,312–1,317	.05	1	9	70	<.04	.58	67	<.6	<.6	150	—	
CDMW1- 14	1,317–1,322	.05	1	9.3	62	<.04	.35	64	<.6	<.6	130	–6.64	–46.15
CDMW1- 15	1,717–1,722	.07	1	8.5	115	.16	.66	146	.9	<.6	195	—	—
CDMW1- 16	1,722–1,727	.08	1	8.5	140	<.04	<.04	142	<.6	<.6	210	—	—
CDMW1- 18	1,732–1,737	—	—	—	180	—	—	—	—	—	—	—	—
CDMW1- 19	1,972–1,977	.21	6	8.1	110	<.04	.44	1,100	2.9	<.6	90	–6.56	–47.5