PRELIMINARY CHLOROFLUOROCARBON AGES FOR GROUNDWATER SAMPLES FROM PRODUCTION WELLS IN THE LAWRENCEVILLE, GEORGIA, AREA

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Abstract. Water samples were collected by the U.S. Geological Survey (USGS) from six production wells in 2001 in the Lawrenceville area, Georgia, for analysis of chlorofluorocarbons (CFCs) to estimate the apparent age of groundwater in a crystalline-rock aquifer (Fig. 1). Apparent CFC ages were calculated by comparing CFCs in groundwater samples to atmospheric CFCs-mixing ratios measured in Niwot Ridge, Colorado, after adjustment for recharge elevation (Plummer and Busenberg, 1999; U.S. Geological Survey, 2004). The apparent CFC age is the time since the recharge water was isolated from air in the unsaturated zone and may provide an estimate of groundwater residence time.

The apparent CFC ages obtained from the samples ranged from mid-1950s to modern (post 1995) (Table 1). The oldest groundwater ages were from samples collected from well 13FF21, which derives most of its yield from a single high-yield (120 gallons per minute) water-bearing zone that shows no interconnection with the regolith. The youngest groundwater age was from a sample collected from well 14FF55, located about 4,000 feet from an operating municipal production well; well 14FF55 taps multiple water-bearing zones ranging in depth from about 65 feet to about 420 feet. Some of the samples are interpreted, using the ratios of the CFCs, to represent a binary mixture of young (less than 60 years) and old (greater than 60 years) waters (Plummer and Busenberg, 1999). Using a simple binary mixing model for CFC-113/CFC-12, most of the samples are interpreted to be mixtures of young and old waters, probably derived from different water-bearing zones in each well. Plots of CFC-113 versus CFC-12 indicate that about one-third of the samples lie on or near the piston flow line, indicating groundwater flow can be described in terms of a simple piston-flow system (Fig. 2).

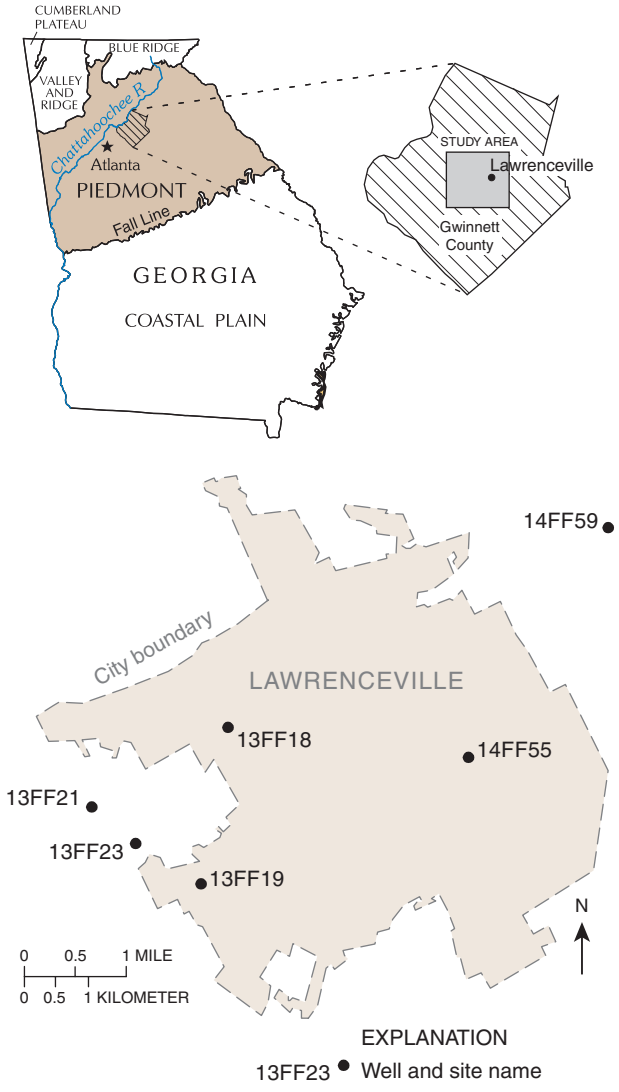

Figure 1. Study area and locations of wells sampled for chlorofluorocarbons, Lawrenceville, Georgia, 2001.

Table 1. Chlorofluorocarbons results for water samples collected from six production wells during aquifer testing, August–October 2001, Lawrenceville, Georgia. Well locations are shown in Figure 1.

[bls, below land surface; CFC, chlorofluorocarbons; ft, foot; do., ditto; pg/kg, picograms per kilogram]

Well depth and open interval (bls)	Sample 1 name	Sample type	Sampling date	Ampoule number	Concentration in solution			Age based on	Estimated CFC age	Comments
					CFC-11 (pg/kg)	CFC-12 (pg/kg)	CFC-113 (pg/kg)			
13FF18 – 550 ft	13FF18a	Start pump[2]	9/4/01	2	9.23	242.32	3.07	CFC-13	Late 1960s	CFC-12 suspect
Open 55 to 550 ft	do.	do.	do.	4	9.74	235.84	4.73			Excess CFC-12
	do.	do.	do.	5	11.79	234.07	4.04			Possible mixture
	13FF18b	End pump[3]	9/10/01	2	56.65	330.06	6.32	CFC-113	Early to mid-1970s	CFC-12 suspect
	do.	do.	do.	4	56.16	334.88	7.41			Excess CFC-12
	do.	do.	do.	5	53.45	327.66	6.96			Possible mixture
13FF19 – 477 ft	13FF19a	Start pump	10/2/01	2	282.96	413.33	7.55	CFC-11, -113	Mid-1970s	CFC-12 suspect
Open 65 to 477 ft	do.	do.	do.	4	366.28	482.87	8.85			Excess CFC-12
	do.	do.	do.	5	320.89	440.63	8.06			
	13FF19b	End pump	10/5/01	2	208.92	257.44	20.99	CFC-113	Mid-1960s or younger	
	do.	do.	do.	3	99.35	201.39	0.00			
	do.	do.	do.	4	105.01	213.90	3.17			
13FF21 – 505 ft	13FF21a	Start pump	8/21/01	2	5.59	27.74	3.29	CFC-12, -113	Mid- to late 1960s	Possible mixture
Open 40 to 505 ft	do.	do.	do.	4	60.75	94.62	18.33			
	do.	do.	do.	5	16.12	55.28	6.08			
	13FF21b	End pump	8/24/01	2	17.44	51.43	3.96	CFC-12, -113	Mid-1950s	
	do.	do.	do.	3	3.73	10.55	0.00			
	do.	do.	do.	5	22.05	41.31	6.41			
13FF23 – 498 ft	13FF23a	Start pump	9/18/01	2	16.33	75.97	6.23	CFC-12, -113	Mid- to late 1960s	
Open 30 to 498 ft	do.	do.	do.	4	9.22	43.24	5.12			
	do.	do.	do.	5	9.18	52.35	4.48			
	13FF23b	End pump	9/21/01	2	16.08	84.39	3.06	CFC-12, -113	Early to mid-1970s	
	do.	do.	do.	3	16.21	84.82	2.83			
	do.	do.	do.	4	22.17	82.16	6.10			
14FF55 – 450 ft	14FF55	End pump	8/17/01	3	588.21	1,194.92	82.86	All	Possible modern	CFC-12 suspect
Open 63 to 450 ft	do.	do.	do.	4	60.50	671.99	100.00		(post-1995)	Excess CFC-12
	do.	do.	do.	5	55.34	466.60	96.00			
14FF59 – 470 ft	14FF59a	Start pump	10/10/01	2	57.73	2,896.28	13.41	CFC-113	Mid-1960s or younger	CFC-12 suspect
Open 35 to 470 ft	do.	do.	do.	4	10.33	3,283.58	3.10			Excess CFC-12
	do.	do.	do.	5	14.39	3,230.42	3.31			Possible mixture
	14FF59b	End pump	10/12/01	2	1,049.42	277.69	39.15	CFC-11, -113	Mid-1960s or younger	CFC-12 suspect
	do.	do.	do.	4	67.20	3,626.52	2.09			Excess CFC-12
	do.	do.	do.	5	62.01	3,597.90	2.59			

[1]Three separate ampoules analyzed for each sample.
[2]Sample collected about 1 hour after starting aquifer test.
[3]Sample collected about 1 hour before the end of 72-hour aquifer test.

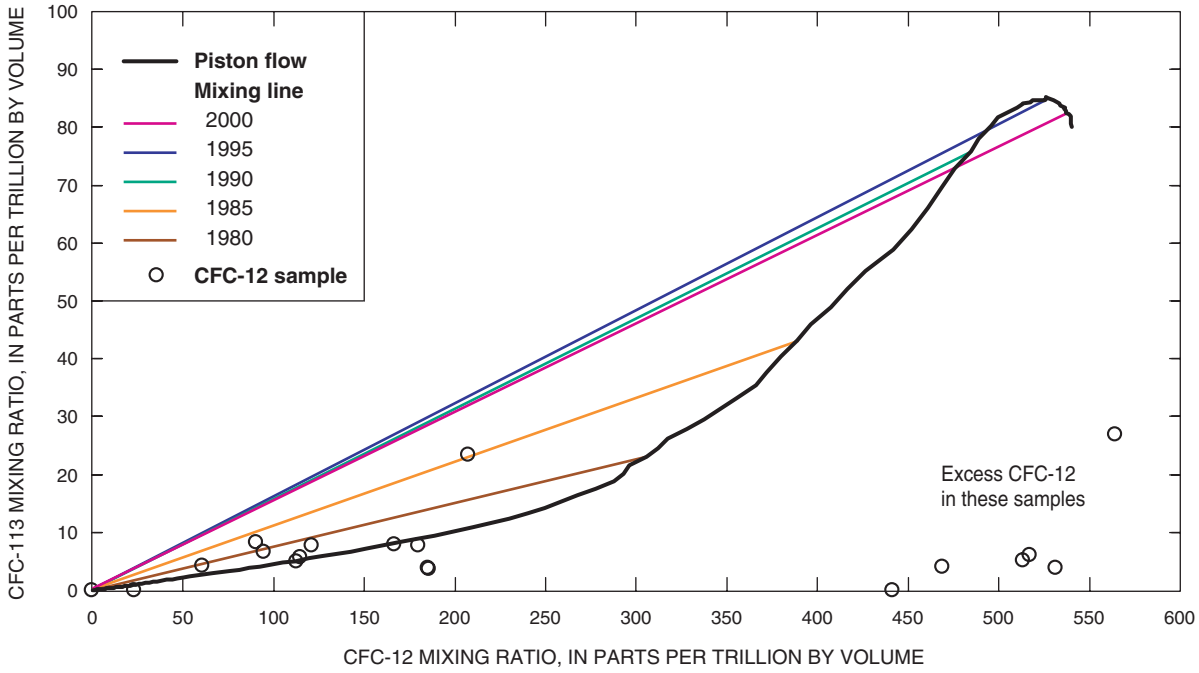

Figure 2. Mixing ratios of chlorofluorocarbon-113 (CFC-113) and chlorofluorocarbon-12 (CFC-12) for samples collected from six wells in Lawrenceville, Georgia, August–October 2001. The cluster of samples along the piston-flow line was obtained from two of the six wells sample. Other samples had excess CFC-12 and plot to the lower right or plot off the chart.

At five of the production wells, samples were collected at the beginning and end of a 72-hour pumping test. At two production wells (13FF21 and 13FF19), the apparent CFC age increased during the period of pumping. Conversely, apparent ages decreased in samples collected from well 13FF23. Samples from two other wells (13FF18 and 14FF59) did not show any significant differences in beginning apparent ages and ending apparent ages.

The study of CFCs in water samples provides preliminary estimates of apparent groundwater ages and has helped to refine hydrogeologic concepts related to the source(s) of water to the production wells in the Lawrenceville area. Limitations to the CFC method, however, include (1) presence of excess CFCs, which indicates anthropogenic sources at several of the wells; (2) potential microbial degradation of CFCs (in particular CFC-11), which decreases the concentration over time and influence the interpretation of the data; and (3) mixing of young and old groundwater, which was especially problematic in production wells deriving water from more than one water-bearing zone.

The USGS conducted this study, in cooperation with the City of Lawrenceville, while investigating the hydrogeology and ground-water resources of the area.

LITERATURE CITED

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