The chemical composition of Earth's atmosphere IX: residence time

Mole %	*Name*	*Chemical formula*	***Residence Time***
78.084	Nitrogen	N_2	**10^6-10^7 years**
20.948	Oxygen	O_2	**3000-10,000 years**
0.934	Argon	Ar	**Forever**
0.004 - 4	Water vapor	H_2O	**~10 days**
0.0385 (385 ppm)	Carbon dioxide	CO_2	**2-10 years**
0.001818 (18.18 ppm)	Neon	Ne	**Forever**
0.000524 (5.24 ppm)	Helium	He	**~10^6 years**
0.00017 (1.7 ppm)	Methane	CH_4	**2-10 years**
0.000114 (1.14 ppm)	Krypton	Kr	**Forever**
0.00005 - 0.0010	Stratospheric ozone	O_3	
0.000055 (0.55 ppm)	Hydrogen	H_2	**4-8 years**
0.000033 (0.33 ppm)	Nitrous oxide	N_2O	**5-200 years**
0.0000050 - 0.0000200	Carbon monoxide	CO	**60-200 days**
0.0000087 (87 ppb)	Xenon	Xe	**Forever**
0.0000010 - 0.0000500	Tropospheric ozone	O_3	
0.0000005 - 0.0000020	NMHC	C_xH_y	
0.0000000540 (540 ppt)	CFC12	CF_2Cl_2	**>80 years**
0.00000005 (500 ppt)	Carbonyl sulfide	OCS	**~ 2 years**
0.0000000265 (265 ppt)	CFC11	$CFCl_3$	**~80 years**
0.00000001 - 0.000001	Hydrogen peroxide	H_2O_2	**1 day**
0.00000001 - 0.0000001	Formaldehyde	CH_2O	**5-10 days**
0.0000000098 (98 ppt)	Carbon tetrachloride	CCl_4	**≥ decades**
0.0000000065 (65 ppt)	Methylchloroform	CH_3CCl_3	**~7 years**
0.000000001 - 0.0001	Nitrogen oxides	NO_x	**A few days**
0.000000001 - 0.0000001	Ammonia	NH_3	**A few days**
0.000000001 - 0.0000001	Sulfur dioxide	SO_2	**hours to weeks**
0.000000001 - 0.00000001	Dimethyl sulfide	CH_3SCH_3	**<1 day**
0.0000000001 - 0.00000003	Carbon disulfide	CS_2	**~40 days**
0.0000000005 - 0.00000005	Hydrogen sulfide	H_2S	**<5 days**
0.0000000002 (2 ppt)	Hydroperoxyl radical	HO_2	
0.000000000005 (0.05 ppt)	Hydroxyl radical	OH	**≤ a few seconds**

The table at left is organized to have concentration decrease downward, but residence time generally decreases downward through the table too. One explanation of that trend is that any component with a long residence time has sufficient time to accumulate to a relatively large concentration.

A second explanantion has to do with chemical reactivity. The components with the longest residence times are the noble gases, which are chemically inert. The two components with the next longest residence times, N_2 and O_2, are triple-bonded and double-bonded molecules and thus slow to react. On the other hand, many of the components with shorter residence times are not fully oxidized and thus reactive in the atmosphere (e.g., CH_4, CO, NH_3, and H_2S). Finally, the shortest residence times belong to the highly reactive radicals, HO_2 and OH.

These thoughts combine to produce a general explanation of the table at left. Lower in the table, more reactive species are removed by their reactions and thus have short residence times, and their removal means that they aren't very abundant. Higher in the table, less reactive species aren't removed so readily and thus have long residence times, which means that they accumulate to be more abundant. Add in the propensity of Earth's biotia to produce N_2 and O_2, and you've got a good explanation of the patterns in the table.

Sources: see Part I of this series.