Rapid fall of the K/T sulfuric acid aerosol particles and oceanic pH reduction

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Geologic records show that numerous amount of sulfate was vaporized by the K/T impact. Experimental and theoretical studies of chemical reactions in impact vapor clouds strongly suggest that the degassed sulfur may have formed sulfuric acid aerosols quickly. Blockage of the sunlight by the sulfuric acid aerosol and sulfuric acid rain are ones of the most plausible killing mechanisms of the K/T event. The stay time of the sulfuric acid aerosols in the atmosphere decides whether the blockage of the sunlight lasts for a long period of time and whether strong acid rain falls in a short time. Several previous studies [e.g., Pope et al., 1994 and Pierazzo et al., 2003] estimates that the stay time of the sulfuric acid aerosol particles are longer than several months. However, these studies do not consider the interaction between the sulfuric acid aerosol particles and silicate dust particles. In this study, we assess whether the sulfuric acid aerosol particles coagulated with the silicate dust and estimate the stay time of the sulfuric acid aerosol particles in the atmosphere. We also estimate the reduction of pH in the oceanic upper layer during the fall of the sulfuric acid.

The results indicate that most of the sulfuric acid generated by the K/T impact would be swept out by the silicate condensates and fall down within a few days. The average residence time of a sulfuric acid aerosol in the atmosphere is estimated shorter than one day. The calculation results show that more than ~90% of the sulfuric acid aerosol particles would coagulate with the silicate condensates and fall down within 10 days. Approximately 50 % of the total mass load falls down to the ground within one day, and approximately 70 % falls down within two days. Such rapid fall of the sulfuric acid would lead to extremely intense global acid rain.

The extremely short timescale of the fall of the sulfuric acid may dramatically changes the previous view on the role of the sulfuric acid on the K/T event. Previous studies estimate the residence time of the sulfuric acid aerosol longer than 6 months. Such slow addition of the K/T sulfuric acid does not significantly change the pH in the global ocean surface layer. The insensitivity of oceanic pH to the acid input occurs because carbonate buffer prevents a dramatic change in the pH in the marine surface water. Their estimate of the critical mass load that can drastically decrease the pH is ~6 x 10^16 mol of sulfuric acid. This value is larger than reasonable estimates of the K/T sulfuric acid. However, the calculation results of the present study indicate that the sulfuric acid generated by the K/T impact would fall on the ground/ocean surface within a few days. This timescale is much shorter than the timescale of the gas exchange between the atmosphere and the oceanic upper layer. The carbonate buffer in the marine surface layer is significantly weakened when gas is not exchanged between the atmosphere and the oceanic upper layer. Thus, such fast addition of sulfuric acid would result in drastic decrease of the pH in most of the marine surface water even if the amount in the sulfuric acid is much smaller than the critical mass load estimated. The rapid fall of the sulfuric acid would result in drastic decrease of pH in the global ocean surface layer.