Response to questions raised by anonymous Reviewer #2

Reviewer #2: "This manuscript provides a database of (U-Th)/He ages (almost 3000 ages) and U-Th contents of goethite samples from different countries and weathering environments in the world. Authors attempt to assess the influence of environmental conditions on changes in the frequency of precipitation and preservation of goethite in weathering profiles. I agree with the authors that their data set may contribute to understanding goethite (U-Th)/He dating of supergene weathering processes. I think this work is suitable for Geochronology, and they have interesting data set to contribute. However, in the paper's current form, I think with a modest and careful effort to revise the manuscript, this will make a nice addition to this journal. My only concerns are: (1) Authors provide a large amount of information on ages and U-Th contents of goethite, but discussion and interpretation are limited; (2) the figures need to be improved; and (3) implication on paleoenvironmental and paleoclimatic studies."

We thank the reviewer for encouraging the publication of our manuscript. To fulfill the reviewer's requests, we will:

1. Create a new discussion section with interpretation of the (U-Th)/He results.
2. Improve figure quality by adding labels, increasing font size, coloring of countries in the map (Figure 1) for which (U-Th)/He data are available. In addition, a new figure will be created with photomicrographs and/or SEM images of different types of goethites.

Reviewer #2: "1. "Introduction" - This section authors proposed that goethite dating can provide information on global environmental conditions, but they do not clearly explain the links between goethite formation and environmental conditions. I also suggest authors may add some explanation on why goethite is important and profit to (U-Th)/He dating; why other iron-oxides (lepidocrocite, hematite, magnetite, limonite) are not widely used to (U-Th)/He dating? Is it related to well preservation, crystallinity, high U-Th contents, or specific paleoclimatic condition?"

Goethite precipitation depends on solution chemistry, H_2O availability, pH, and temperature. Temperature and pH have a greater effect on precipitation rates. Ph also plays a role in the incorporation of other cations (e.g., Al) in the goethite structure. The literature about the conditions under which goethite precipitates is vast, and we will introduce some of the most important ideas and the implications to the use of goethite as an environmental marker.

We will also expand our introduction section to explain why goethite until now dominates in studies of surface processes that applies the (U-Th)/He method.

Reviewer #2: "2. "Geological Environments" and "Types of goethite"-Authors spend the great length to describe the geological environment, occurrence, geochemical characters, and Eh-Ph of the goethite. I think those two sections should be combined and reduced, if authors add a summary table that list the location, elevation, profile, depth, paleoclimatic conditions, goethite occurrence (colloform, massive, infilling, pisolitic....), crystallinity, mineralogical associations (goethite+hematite+clay, goethite+magnetite+ilmenite, goethite+Mn-oxides, goethite+gibbsite+gold, goethite+malachite+azurite+cuprite+native copper+chalcocite, ...), geochemical composition (Al, Cu, Ni, P, REE, Co, U, Th, U/Th...), and (U-Th)/He ages of different

geological environments, then it is easy to compare the goethite in different geological environments."

Thank you for the suggestion. We will summarize the relevant information in a table.

Reviewer #2: "3. "U and Th concentrations in globally distributed goethites"- The U-Th concentrations in goethite are very interesting, I hope author may give more interpretation of these results. First, authors only use the reported data in ppm to plot, thus some information may loss. In this case, I suggest authors may plot with element molar ratios, such as U/Sm, Th/Sm, and U/Th…Because we find the U and Th concentrations are variable within a weathering profile and even within a single hand-sample, but U and Th commonly show a strong positive correlation, this indicates they have similar U/Th ratios in certain surficial environments, thus it possibly reflects the source of weathering rocks or others. Second, I suggest U vs Th concentrations plates of distinct geological environments may plot in a single plate, it is easy to compare the U-Th distributions at different condition. I also suggest authors may add U/Th ratios vs deep or Sm/Th ratios, and then compare and discuss the geochemical characters of goethite in different geological environments."

We thank the author for the suggestions. We will incorporate more information on U and Th contents in the new version of the manuscript.

Reviewer #2: "4. "The global distribution of goethite (U-Th)/He ages"-The (U-Th)/He age distribution and age vs eU plots of goethite samples from distinct environments are significant. First, the age distribution plots (Figure 4) show the ages from the most regions (Canada, USA, China, Tunisia, French Guiana, Suriname) are almost younger than 20 Ma, some regions (Brazil, Australia, Switzerland) show goethite formed since >60Ma, but goethite from Morocco formed at 40-100 Ma. I expect authors do not just show the age distribution, but add some explanation on why these regions have distinct age distribution patterns. Second, although eU vs (U-Th)/He age plots do not show positive correlation, goethite with old ages (>~80Ma) have very low eU, especially samples from lateritized continental sediments show low eU in the old age sample but high eU in the young age sample. Is it possible that high eU goethite may damage the mineral's structure, and thus the He loss of high eU samples cause the young age or U loss of sample cause the goethite have low U and high ages?"

Again, we thank the author for the suggestions. We will discuss the global distribution of (U-Th)/He goethite ages in more detail in the revised version of the manuscript.

The lack of positive correlation between eU (U + 0.235 * Th) concentration and ages suggest that radiation damage is not a significant factor controlling He retentivity in goethites. Crystallite size distribution appears to be the main factor controlling He release from goethite. Now, the amount of U and Th in a sample will depend on the availability of these cations in solution. For example, multiple cycles of goethite dissolution in oxidizing environments will favor U mobilization towards lower horizons in the weathering profile. Consequently, the young goethites precipitated at depth will become enriched in U.

Reviewer #2: "5. "Summary"-I expect to what kind of goethite samples are suitable for (U-Th)/He. Also, authors may add some approaches for goethite (U-Th)/He age interpretation in future works; such as, more geochemical works (such as U, Th, Al, P, Si, Ti, Ni, Cu, REE…) on goethite is benefit to

understand weathering processes, the researches on the crystallinity of goethite are used to evaluate the He retentive, and stable isotopes (C, N, H, O, Fe, Cu, Zn…) may reflect the paleoclimatic conditions during the goethite formation."

Once again, we thank the author for the suggestions. We will discuss the issues suggested above in the revised version of the manuscript.