Mark Isselhardt

Critical Writing (Geology 371)

4/1/09

Reusser L., et al., 2009. Tracking fluvial sand through the Waipaoa River Basin, New Zealand, using meteoric ^{10}Be. **For submission to Geology**

The authors present research of meteoric ^{10}Be analysis as a tool for characterizing the movement of river sediment. Sediment samples obtained systematically from the headwaters, main tributaries and mainstem of the Waipaoa River basin, New Zealand show a range of concentration of ^{10}Be from 1.5 x 10^6 d to 14 x 10^6). Some upper reaches of the rivers tributaries are experiencing high rates of erosion while others are not. The areas with a history is severe erosion contain sediments with significantly lower concentrations of ^{10}Be compared with more stable areas and the mainstem of the Waipaoa River. The authors went to great lengths to check their methods (repeat sampling and using multiple labs). Results suggest that ^{10}Be concentrations in sediment could be a rapid and useful source of information about sediment movement and basin erosion dynamics.

This paper presents original research in a concise and concentrated manner. It deserves to be published in Geology. The abstract succeeds in describing the important thrust of the research including the major findings. The introduction provides some background into the geologic and human issues related to soil erosion and the problems associated with its quantification (including other techniques analyzing ^{10}Be concentrations). The introduction ends with a solid description of the work about to be presented. The next section brings the reader up to speed on how and at what magnitude, meteoric ^{10}Be is formed. There is another section that describes the geomorphology of the Waipaoa River basin including some of the extreme erosion that has taken place due to human landuse. This is a helpful section and lets the reader to get acquainted with the study site quickly. The methods section reviews both field and lab procedures. This section should explain in a bit more detail how the sediment samples were generated. There should also be some additional information about how a given area was classified (gullied-non gullied). It appears like this was done with the help of GIS. There should be some space given to a more detailed description of the techniques and definitions of a gully. The results section says that samples were strategically taken from above and below the junction of a tributary and the mainstem. Is this sand taken from under moving water? Is there a citation for this lab of field work that could explain the techniques in more detail? The results section is brief but includes the necessary information and this is to be expected given the actual number of tests performed. There is also a section that describes repeated testing that was undertaken the following year. The results suggest that whatever

temporal variation in the ^{10}Be concentration may exist is not large enough over the sampling interval (~9 months) to be reflected in the samples. The discussion section (although not titled as such) does a good job analyzing the results. There is a lot of emphasis placed on the inverse relationship of % gullied terrain versus ^{10}Be concentration. It appears as though there is an equally strong positive relationship along the mainstem between total basin area (km^2) and ^{10}Be concentration. The implications section at the end puts forward how the authors feel meteoric ^{10}Be concentrations can be used. It would be interesting to know if the authors feel this technique could be applied broadly or is limited to certain areas of the earth.

Figures 1-3 do a great job bringing the reader to the study site. They all have a crisp, clear layout and provide relevant information. The detailed relief map underlying Figures 1-3 could be simplified a bit while still telling the story effectively. Figure 3's pictures are terrific and the insets help connect to the various sampling locations (maybe a possible cover shot in there?). Figure 4A was a bit confusing. The reader is forced to flip between Figure 1, the results section and Table one in order to put together the story of where each point on the line is from. If Table 1 is only going to be available as supplemental material the reader may get lost. In 4A, the relationship between ^{10}Be concentration and basin area appears to be clear until the tributary samples are added. The use of symbols drawn with a flag corresponding to scale for area is helpful but it also adds another element that must be digested.

It looks as though you have exceeded the page requirements (It's hard to see how the authors could trim it down to 4 pages). Other than that it seems like the submission requirements have been followed. There are a few minor mistakes in grammar and will be shown on the hard copy.

A few more odd ball questions:

- Do the sediment samples from the severely gullied basins reflect just what ^{10}Be has been deposited recently, such as since the last major erosion event? This was touched on in lines 224-226.
- Are there other human activities that would influence how ^{10}Be was deposited on the landscape?

Great paper, good luck with publication.

Lee Corbett
GEOL 371
4/1/09

Review of: Tracking fluvial sand through the Waipaoa River Basin, New Zealand, using meteoric ^{10}Be
Authors: L.J. Reusser and P.R. Bierman

In this manuscript, the authors present data from a study that uses meteoric ^{10}Be to track sediment movement and erosion rates in the heavily eroded Waipaoa Basin, New Zealand. The method is novel and has important implications to the field of Geomorphology since it allows researchers to easily investigate sediment movement and allows analysis to be performed in basins that contain no quartz. In addition, the findings add clarity to the current understanding of the behavior of quickly eroding basins.

Overall, the manuscript is well written and polished. The ideas are presented in a logical fashion, and are grouped together effectively in paragraphs and sections. The level of detail seems appropriate for *Geology*. Finally, the authors do a good job of looking at the larger ideas behind their research in the introduction, discussion, and conclusions.

Please refer to the hard-copy edited version of the manuscript for small comments regarding structure and rhetoric. In addition, I have several broader comments:

1.) Most importantly, I felt like there was a couple missing pieces in your discussion about how ^{10}Be is used to study sediment movement. In your "Meteoric ^{10}Be" section, you do a good job describing what ^{10}Be is, where it comes from, and how it gets transported. However, you don't fully close the loop and describe how you're going to use it to understand how sediment is moving. I'd suggest explaining that, in a rapidly eroding landscape, sediment that is being brought to the surface quickly has had little time to interact with rainfall and therefore has lower concentrations of ^{10}Be. Since *Geology* is such a broadly focused journal, adding background information like this will greatly help your readers who aren't familiar with Geomorphology.

2.) A similar brief overview might be helpful in your abstract. You jump right from talking about big picture ideas (sediment sources, land clearing, etc) to giving ^{10}Be concentrations, without describing what ^{10}Be is and why it is useful. You don't need a lot of detail here, but a single sentence would be very helpful for readers, especially if they just want to get a quick idea of what your paper is about.

3.) Throughout your paper, you celebrate the idea that the meteoric ^{10}Be method can be used in basins that contain no quartz. I agree that this is an important finding of your work. You don't, however, mention this in the "Implications and Future Research" section. Maybe it deserves to be in there if you think that it is important enough to be in the abstract.

Good luck with edits and publication. Well done!

Lee

Amanda Holland review

Meteoric 10Be can be used to understand the sources of sediment on the landscape. This paper presents an new application for this measure and found a tight correlation of basin area and sediment source to concentrations of meteoric 10Be. Lower concentrations were found in tributaries that were unstable and highly gullied and higher concentrations were found in more stable headwaters and mainstem samples.

This paper does a great job of laying out the material and getting to the point of why a point is relevant and included. The abstract starts off very strong but I a few sentences could be reworded to make the statements more upfront and clear in the sentence structure. I was a little thrown by the worked 'diluted' on line 56, page1 as I am reading it as the lower concentrations of input are being 'diluted' with higher concentrations. And if this is a correct statement the use of diluted here makes me naturally thing the opposite is happening. Not a big point but this tripped me up here and later in the paper when it was discussed. The introduction does a great job of describing other methods used in the field and the justification for why you are trying this method.

I did not get a good sense for the uncertainty and spatial variability of the examples presented in the Meteoric 10Be paragraph starting on line 98. Later in the paper you provide results that show good temporal variability from you lab results (and have clear section titled on this topic). As this section mentions uncertainty to start and then gives some other examples that provide approximate values, I think it would be good to have another sentence later in the discussion that states how you either found or did not find this element varied spatially. If this point is made by your landscape results of concentrations from basin area then I would add this point to those statements (this maybe in there but I missed?). Table 1 provides a wealth of information about the sites but I did suggest you could include a separate table that goes over the 'experimental' design by including the data on lines 156-159 or you could reference the figure as it mentions replicates and give a bit more description. I thought it could help describe with more detail how the samples were chosen as I don't see 18 points on Fig1 but I do see notes of 'rep' as mentioned in the text here.

The section discussing how the tracer is useful for fluvial sediment sources had good repetition to the results. I know you are looking for places to cut down material but I think repeating the overall trend of concentration changes with which landscape feature/basin and tying them into figures is important. I know it helped me to understand and remember which landscape features were associated with the results.

The final section on implications and future research has a great tie to information mentioned in the beginning and providing a bit more depth with examples of the questions this can answer.

Tracking fluvial sand through the Waipaoa River Basin, New Zealand, using meteoric 10Be

Reusser and Bierman

Review by Andrea Pearce
3/31/09

Reusser & Bierman present a method for using 10Be to track the relative erosion rates throughout a rapidly eroding basin in New Zealand. They content that the sand in the river should be well enough mixed to represent an average of the upstream gully erosion. Fluvial sand was collected and processed and analyzed via crazy isotopic techniques to yield a 10Be concentration. There is a very nice relationship between the drainage area and 10Be concentration throughout the watershed. The authors suggest that a technique such as this could be used to help identify which sub basins in a watershed are the greatest contributors of sediment downstream.

This manuscript is well written, clear and concise. They are well thought out, informative and look pretty slick. The overall organization of the paper is logical and effectively guides the reader through. The test basin is reported to be eroding rapidly and I'm curious how well resolved differences in 10Be would be in a more slowly eroding basin.

This manuscript presents a new method and seems well suited to the goals of Geology and is worthy of publication at this journal. I recommend it be accepted with minor revisions. Minor editorial notes are included in the attached copy of the manuscript and more significant comments follow:

- Lines 241-246 – This sentence is long hard to follow. Try breaking up into two sentences.

- General Comment: I'm not entirely sure I understand how it's all working, but it seems like the 10Be measurements represent relative erosion rates within the contiguous catchments. You say that this could be used as a diagnostic tool in other watersheds. Are significantly slower erosion rates going to reduce 10 Be concentrations? Will measurement error overshadow the signal you're trying to pick up?

Afraid I'm not too much help with this one. Overall this looks great.

Review by: Carrie Pucko

Title: Tracking fluvial sand through the Waipaoa River Basin, New Zealand, using meteoric 10Be

For submission to: *Geology*

Authors: L. Reusser and P. Bierman

Summary: This paper proposes a new method of tracking sediments through river systems using Be that were not able to be measured using old techniques because the parent material did not contain quartz. The new method uses meteoric Be which is rained out of the atmosphere, instead of *in situ* Be formed from the exposure of soil to cosmic rays, for analysis. The amount of Be found in sediment at different points along a mainstem and in tributaries to a river can indicate where sediments are coming from and how much a particular reach is contributing to sediment loads. This study was done on a basin in northern New Zealand. What a horrible place that must have been to do fieldwork...how can I get in on that? The study found that the majority of sediment was contributed by deforested, unstable slopes in the northern reaches as opposed to the more stable and forested reaches in the eastern and western portions of the basin. This was figured out using Be concentrations since sediments with low amounts of BE have not been exposed to the atmosphere for a long period of time indicating they erode rapidly. Sediments with high amounts of Be have been collecting atmospheric Be for a longer amount of time, indicating stability.

Review:

I thought this paper was extremely clear and well written. Knowing absolutely nothing about cosmogenic isotopes or Be sediment analysis going in, I feel like I understand the logic behind the technique as well as what different patterns of Be in sediment can tell us about a catchment. I do think more emphasis should be placed up front on the fact that this allows researchers to use Be as an indicator of erosion rates in many more places than they could previously due to bedrock restrictions. I thought your methods and conclusions were logical and easy to follow and that your results were solid. This was well supported with the emphasis you placed on replicability both temporally, and with the work done in different labs.

There were only a few points at which I found myself confused, or mistaken which I will outline below.

1) I got confused with the term "*in situ"* although I suspect geologists will understand that this means cosmogenic Be, I found myself at one point thinking it was something else. From my understanding now I think *in situ* Be means that the Be10 was <u>formed</u> on site through exposure to cosmic rays, not just found there.
2) Would you only use the analysis of meteoric Be when the cosmogenic Be is not available? Or would the use of meteoric Be be preferential anyway?

3) Have any other studies been done with meteoric Be? Do they get similar results?
4) Is it reasonable to assume that the more stable eastern and western catchments are putting less sediment in to the Waipaoa River than the northern reaches? If so, wouldn't that make the proportion of the sediment coming from the north even greater? Are you able to get at the actual amount of sediment coming from each location, or only the Be contribution?
5) In terms of paper organization, the only part I found a little confusing was the beginning of the paragraph on line 236 on page 8. The beginning of this paragraph seemed to be summarizing some of the material in the previous paragraphs and I was expecting it to be a summarizing paragraph or conclusion paragraph of some kind. I would think about making these last two paragraphs of this section into a conclusion/ wrap-up with their own heading, or cutting out the more summarizing material to have it fit more with the rest of the section.
6) I thought that the figures you made for this paper were aesthetically very nice, though I have a small suggestion for figure 1 and one for figure 2. In figure 1, could you make the non-basin area a different color or shade from the basin. At the moment the individual tributaries are darker, but toward the mouth of the river, it is the same shade as the rest of the map. Sometimes it's just hard to get perspective on these things. It's also one of those things that if you've been looking at it for a long time, you can't understand how someone could not see it correctly. In figure 2, I think you just need to draw in the very end of the river like you did in figure 1.

Again, overall this was a very enjoyable paper with a clear utility and easy to understand methods and results.

Joe Bartlett

3/31/09

Review of Reusser and Bierman

The purpose of this study was to demonstrate and describe the use of meteoric 10Be for quantifying sediment sources in a river basin. Beryllium is a fairly common isotope for quantifying sediment sources, but most studies rely on in-situ 10Be which is only found in quartz. This study utilized atmospherically derived meteoric 10Bewhich is continuously generated from spallation of N14 by cosmic rays and is deposited at a relatively constant rate worldwide. Sediment flux from areas of drastically differing erosion rates was computed by measuring 10Be levels in river sediment. Sediment from areas of high erosion are exposed to meteoric 10Be for a much shorter time than more stable areas, allowing for estimation of sediment sources. This study also found that their results were highly reproducible temporally. Overall, they demonstrated the meteoric 10Be is a useful tool for quantifying sediment sources in river basins.

This paper is very good and should be a great fit for Geology. It is well written and very easy to read and comprehend. There are a few grammar and wording issues, but the content and figures are good. The abstract could benefit from a clearer purpose statement and a better explanation of the 10Be process, and a mention of the temporal reproducibility analysis. The results description in the abstract could be condensed if the paper needs to be shortened. The introduction is good and very concise. It could benefit from a brief comparison of Be to other isotopic tracers, unless it is more commonly used than I am aware of. The methods are also good and concise. The results segue nicely into the discussion of 10Be as a useful tracer. The implications section is very good but there is no mention of future research. Did you identify any potential problems with this method?

This paper should be accepted with minor revisions, so long as it is the right length for submission. It would take a decent amount of effort to shorten the paper and keep it as easy to read and comprehend. Specific recommendations for improvement are as follows:

- L 45: Consider stating that 10Be is Beryllium
- L49: Awkward and somewhat run-on sentence
- L62: This doesn't make sense without mentioning in-situ Be first
- L64: Should mention reproducibility analysis in abstract
- L75: Run-on
- L121: Consider adding a sentence to describe the watershed pre-settlement
- L189: Awkward
- L255: Check your numbers here, the Te Weraroa is contributing 5 to 1 sediment/area while the overall gullies contribute 7 to 1
- L257: Confusing sentence
- L261: No mention of future research

April 1, 2009

UVM internal review of:

Tracking fluvial sand through the Waipaoa River Basin, New Zealand, using meteoric ^{10}Be

Authors: Lucas J. Reusser and Paul R. Bierman

During the course of this study the landscape stability of the Waipaoa River Basin, New Zealand was evaluated using cosmogenic ^{10}Be. Although ^{10}Be has been used in other instances for stream evaluation insitu forms, contained only in quartz, are quantified. Due to the lithology of the Waipaoa Basin being primarily composed of claystone and other sedimentary rocks lacking quartz composition, insitu techniques can't be used as they normally would. Samples of alluvial sediments were taken along the main stem of the river as well as several of the major tributaries that enter into the watershed. Curve fitting was then conducted to assess the relationship between ^{10}Be and stream basin characteristics. High r^2 values were found in the relationship between ^{10}Be and basin area was found to be 0.92. Perhaps the most interesting result of this study was the high r^2 value found for the relationship of ^{10}Be and the percentage of the contributing watershed that was gullied due to intense erosion of the area.

This paper displays great overall quality. The writing in this paper gave the reader enough information on this topic to easily understand the topic of the paper as well as the significance of the results. Some rewording may even further aid in the reader's understanding of the subject. The data in this paper was also of great quality, though the small sample set may be somewhat disconcerting to some readers. The main strength of this paper was primarily founded in figure 4 where regression analysis was done and clearly presented.

Due to the significance of data and results of this paper it should be accepted, but with minor revisions. Some figures seemed unnecessary or redundant while others could be expanded upon or broken up to increase the impact of this paper. Understanding that this journal appreciates the most concise of wording there are several areas of the paper where statements are redundant or unnecessary.

- The section on meteoric ^{10}Be does a wonderful job of giving an introduction to cosmogenic beryllium while keeping it concise. Within this section lines 110-113, seem out of place as they are describing the river basins characteristics and could be moved into the following section.
- The abstract of this paper does a nice job of summing up the rest of the paper. Though a bit of a gap is left at the end as it mentions items pertaining to insitu analysis before the reader knows why quartz is important. This could easily be avoided by simply saying that a cosmogenic approach may be used where the insitu techniques are not possible.
- Figure 1 of this paper does well at showing the extent of the basin and the main tributaries. With a little bit of effort and resizing information pertaining to the lithology of the regions could be included in this figure and current figure two could be eliminated.

After carefully reviewing this article there are several items that will need to be corrected prior to submission. The most critical of these is that the article will need to be shortened I am very doubtful that this entire paper 17pgs printed can be resized down to only four. The second item is the figure text it seems to be in 12 pt fonts where it is specified by the journal to be in only 7pt. It also appears to be in a script other than a sans serif, but I could be mistaken on that one. Over all great job and good luck with your submission

Jaron

Too long should not exceed 4 printed pages including everything

4. Prepare your typed, formal review to include the following:
- An introductory paragraph that describes what the paper is about and its main conclusions.
- A second paragraph that presents your evaluation of the paper specifically in terms of: quality of data, logic of interpretations, writing clarity, clarity of illustrations.
- A recommendation and justification of whether the paper should be accepted, accepted with major revisions, or rejected. This paragraph should be followed with a series of bullet points that clearly lay out any major changes are needed to improve the paper.
- Indicate, what if anything needs to be done to make the paper compliant with the instructions to authors.

Jared Nunery
GEOL 371
April 1st, 2009

Review of:

L.J. Reusser and P.R. Bierman, **Tracking fluvial sand through the Waipaoa River Basin, New Zealand, using meteoric ^{10}Be**

For submission to:
Geology

In this manuscript the authors discuss a new method for addressing questions associated with sedimentation rates and origins, especially in basins lacking quartz-bearing lithology that previously restricted the use of cosmogenically derived ^{10}Be isotopic analyses. This work presents a methodology for tracking sediment origins as well as offers insight into the proportionality of sediment generation in different parts of a river basin.

In general I thought this manuscript was very well written, and laid out very well in order to tell a clear story. The manuscript follows a clear, logical path, and does an excellent job of describing how this methodology fits into the existing myriad of extant isotopic analyses used for studying sediment dynamics. In addition the authors show how this study fills a gap in the extant methodologies and offers a novel approach to measuring previously un-measureable systems, due to methodological restrictions. One general point that will help strengthen this paper, is try to be as specific as possible at all times. Substituting general statement and blanket citations (when a point followed by a list of citations), with more specific syntax and provide specific examples from individual studies will help increase the technical rigor of this paper. However, I recognize that this is a very short paper, so it is difficult to include lengthy detailed discussions, but the more specific the better. For specific areas of where increased specificity could be incorporated into this manuscript see the attached hard copy. I believe that addressing the points below will help strengthen an already strong manuscript.

Abstract:

In general the material covered in the abstract was complete, and offered a solid overview of this study, providing a concise description of the findings. My only minor suggestion for the abstract would be to try to shorten the sentences, and separate out longer sentences that have multiple points. This will help clarify the writing, and offer a more concise description that will stick better in the reader's head. One small note of interest, I have never seen the phrase "interrogated cosmogenically", which the abstract concludes with. Though I find this a very interesting idea, I feel that it is miss-representing the applicability of this study. Perhaps changing "interrogated" to studied, analyzed or quantified might help clarify the applicability of this methodology.

Introduction:

The introduction was written in a very easy to follow format and provided a very clear and understandable foundation of geomorphic processes associated with sedimentation. My only concern is that some of this material may be too fundamental for your journal selection, especially the information presented in the opening paragraph. Providing more specific examples of the cited research would help beef up your argument and help to avoid presenting overly fundamental background for the readers of *Geology*. See the hardcopy for places where more specific explanation could be added. One additional point is to address specifically what you mean by land clearing. A large portion of your analyses is built upon the historic land-use of the area, and explained as land clearing. It would be helpful to include in one of the initial times you mention this relationship (like on line 92), what was cleared (forest, conversion of grassland, etc). Though it may seem intuitive, as this is an international audience working in a variety of ecosystems, the more comprehensive the reader's understanding of the study site, the better they will be able to understand and analyze the results of this study.

Explanation of meteoric ^{10}Be:

This was a very useful section, and the authors do an excellent job of explaining the formation as well as limitations of the use of ^{10}Be for isotopic analysis. On line 105 a range of ^{10}Be concentration in relation to climate is given. I am curious if this range reflects the variance both within the cited studies as well as among the different studies. Furthermore, are any of the sites specific to your study area, and if so, this may be important to note, as well as give the concentrations found it that study. It seems that this spatial variation in concentration is quickly discussed, but may have significant impacts in the application of this methodology in different regions.

Study area:

This section was well written and I have only one minor comment. On line 139 and 140 you cite a number of studies related to erosion in the Waipaoa River Basin. Is it possible to incorporate more specifically what aspects of erosion that each of these studies addressed that specifically relate to this study. For example:

> Multiple facets of erosion have been studied in the Waipaoa River Basin, including erosion rates (Derose et al. 1998, Gomez et al 2003), impacts of cyclones on sediment transport (Hicks et al. 2000), impacts of anthropogenic manipulation of basins (Smith 2002)….etc (*obviously I just made up what these studies actually addressed as I have no idea but it gives you the gist of what I am talking about*)

Methods:

The presentation of the methods used in this study was thorough and provided a good description of the overall process. I wonder if you are including any supplementary material that

is more step by step (in an online appendix of the journal or something of that sort), as you are publishing a novel methodology for isotopic analyses, and will hopefully be used by others in the future. One small suggestion is to mention (on line 162) that the same methodology was used in all three labs. Additionally, it might be helpful to specify the actual time span of the temporal replicates on line 158 (i.e. just write the number of years in parentheses).

Results:

Short, concise, and well written, you have some killer R^2 values!

Temporal reproducibility:

You do a good job explaining how the lack of temporal homogeneity may affect analyses, but I feel that this section lacks a solid justification supporting the temporal resolution used in this study. By this I mean, is one year substantial to capture temporal variability. You mention that events such as mass wasting are common in the study area, but do these events occur on intervals of one year, and if not, how does your temporal sampling resolution of one year account for this? In the one headwater system that you saw substantial temporal variations, did a disturbance event occur between sampling periods, or recently that may be causing this variation. I feel that the discussion about the cause of this variability could be elaborated more, as this is a rather significant point.

Use of the tracer section:

This section seemed to flow well until the last paragraph. I wondered if this was where you were setting up your next study as it seemed to be slightly forced into the paper. This may be a result of my own ignorance in geomorphology, but for some reason this section seemed off to me, and more tangential than other parts of the paper. This potentially could be alleviated by elaborating the opening sentence of this section (lines 214 to 216), as this would help set the context that this third paragraph is falling under. Also explaining why it is important to know how concentration changes in sediments throughout river basins. This would have helped me grasp the significance of these findings.

Implications:

This is a great section for tying in where this research will be applicable and how it will add to our extant knowledge of sediment dynamics within watersheds. The one thing I might at add to this section is a brief sentence describing the regions where this technique might as well as might not be applicable.

Overall, great job with this manuscript, and best of luck with the submission. If you have any questions about my comments feel free to contact me (jnunery@uvm.edu)

Paper Title: **Tracking fluvial sand through the Waipaoa River Basin, New Zealand, using meteoric ^{10}BE**
Paper Authors: L. J. Reusser and P. R. Bierman

Reviewer: **Lance E. Besaw**
Date: April 1, 2009

Summary
The authors collect and analyze ^{10}BE in sediment samples from the Waipaoa River, a New Zealand basin. By quantifying the amount of meteoric ^{10}BE in sediments from several tributary sources, the authors are able to determine that although gullied terrain supplies more than half of the sediment transported by the river, despite the fact that gullies cover less than 7% of the landscape. From this they conclude that meteoric ^{10}BE is widely applicable cosmogenic method to study fluvial sediment transport on much of the Earth's surface.

Evaluation
The authors' contributions are very noteworthy and the impact of this paper should be substantial. They have used meteoric ^{10}BE to quantify the amount of sediment transported by a river from different sub-basins. Their data interpretations are very logical and findings should be well received by the community.

Regarding the data quality. The authors state upfront how delivery rates are uncertain. How does this affect the overall applicability of this method at this and other sites?

The data collection and analysis methods appear to be very solid. However, I am not an expert in the field and cannot provide further comment on the data quality.

In general the figure are very useful to the reader and provide pertinent information. The one exception is Figure 4b, which plots %area gullied vs basin area. I am not sure of the importance of this plot. I see the great relationship (R^2=0.98), but the relevance seems to be lacking. As basin area increases the proportion of area gullied decreases – but that does not relate directly to ^{10}BE. It seems like Figure 4a and c are rely this information very well. I would remove Figure 4b.

Recommendation
Overall, I think the manuscript is extremely well written and it contribution is significant. I recommend the manuscript be accepted as is. Only minor revisions might be needed to address these points.

Specific Comments
The introduction is very well written. It is short, to the point and provides the reader with the right amount of information to understand where the paper is going and its overall significance.

The Meteoric ^{10}BE (background) and Waipaoa River Basin (study site) and Methods sections are also very well written.

Meredith Clayton
GEOL 371
1 April, 2009

Tracking fluvial sand through the Waipaoa River Basin, New Zealand, using meteoric ^{10}Be, Lucas J. Reusser and Paul R. Beirman

This paper describes the results of a study conducted in New Zealand's Waipaoa River Basin in which meteoric ^{10}Be was measured in sand samples collected along the mainstem and prominent tributaries. The purpose of these measurements were to identify sources of sediment and to monitor the mixing of sediments as the traveled through the basin from the headwaters to the sea. The Waipaoa Basin exhibits some of the most severe erosion observed on Earth making it an ideal study location. The results of this study reveal that very low concentrations of meteoric ^{10}Be is found in the northern headwaters of the basin where large amphitheater gullies provide large amounts of sediment to the mainstem. Conversely, the more stable eastern and western tributaries contain concentrations of ^{10}Be orders of magnitude higher. The results demonstrate steady and predictable increases in ^{10}Be concentrations downstream indicating that meteoric ^{10}Be monitors sediment mixing in the fluvial network of the Waipaoa River Basin. It is assumed that evidence of meteoric ^{10}Be concentrations at the outlet nearly double that of the headwaters suggests that the gullies provide approximately half of the total sediment load carried by the river, despite the small amount of gullied terrain in the basin. Further, meteoric ^{10}Be would be an effective rapid assessment tool for sediment dynamics and movement within fluvial networks. This is especially useful because ^{10}Be is not limited to basins containing quartz and therefore its measurement in fluvial sediment is applicable in a majority of the Earth's surfaces.

Overall this paper appears to be well organized and well-written, which leaves only minor adjustments in order to prepare it for submission to Geology. I would like to start by emphasizing what is especially strong about this paper so that although I do not have many suggested changes, perhaps you can benefit from knowing what is especially good to replicate in the future. The logic in the paper is very clear making it easy to read and interpret, despite a reader's potential limited knowledge of the specific subject. As tracking sediment in watersheds becomes increasingly popular in efforts such as those aimed at stormwater management, there will be a growing interest in this topic among a more diverse group making clarity of writing and content paramount. The organization of this paper is also particularly useful, especially the section titled "implications and future research." I think that every paper of this type should have a section like this. This section provides something that you can quickly skip to and read to find out why you should care about the results of this study. Abstracts merely touch on this. As for suggested changes, I have noted several places in the text where I would suggest revision of sentence structure to improve clarity and flow, as well as grammatical errors. In general, and not surprisingly given your interest in visual tools, I found the figures in this piece to be great. I would suggest adding something to the legend of Figure 2 that identifies the difference between triangles and circles on the image. I have also noted a small change to some of your charts in Figure 4. The labels on the x-axes are very close to the preceding/following chart making it slightly confusing to look at. I would suggest some sort of additional spacing or alternative layout to make these more easily identified with

the appropriate chart. Again, I found very few things in this piece that I would suggest changing. I think this piece is nearly there. Best of luck with submission!

- Revise sentence structure/grammar where noted in the text
- Add labels for circles and squares to legend of Figure 2
- Consider revising layout of Figure 4 to make x-axis labels more easily identified with the appropriate graph

Review of: Tracking fluvial sand through the Waipaoa River Basin, New Zealand, using meteoric ^{10}Be

By Reusser L, and Bierman P

This paper concisely outlines how meteoric ^{10}Be measurements at different strategic locations in the Northeastern New Zealand catchment basin can be used as a tool to explain local sediment transport. Quantifying the sources of sediment loading in a watershed is important for understanding how to fix impaired fluvial systems, and current systems for determining these sediment loads have shortcomings, such as relying on quartz bearing lithologies for *in situ* ^{10}Be measurements. Meteoric ^{10}Be has been detected as essentially raining across the earth's surface with varying albeit predictable rates. This paper shows a case where measurements of ^{10}Be in different locations in a watershed can provide results that are reproducible in a lab, and temporally reproducible in the field for large catchment basins. The Waipaoa region is geologically susceptible to extreme erosion and the clearance of land for agriculture over the last couple centuries has led to mass sediment transport in the gullied watershed. This paper demonstrates that ^{10}Be concentration in fluvial sediments shows a strong inverse relationship with the percent land area that is gullied; and can therefore provide a rapid description of where the sediments are coming from in gullied catchment areas.

This paper is very strong and is supported by great figures and analytical results. I think after considering some of the questions that are presented from your analysis this paper should be accepted. Figures 1 and 2 provide a good overview of the study sight, I was wondering if you could just use one of these maps in the final draft, mainly to conserve space. I have provided in-line comments on the annotated copy of your paper, and following are a few broad questions that I thought of when reading the text:

- If there is quartz in the lithology is this method still usable, or will the ^{10}Be in the quartz interfere? Furthermore is there ^{10}Be present in the ancient sediments that are being transported by the gullied watersheds? Maybe this could be clarified by stating the half life of ^{10}Be, but I am also not an expert in this subject matter.

- Would replications of these field techniques in other catchment basins help to prove the viability of this analytical technique? Should we expect that you will have a different rate of ^{10}Be deposition in other landscapes, but the relative trends would be the same? Do the actual concentrations of ^{10}Be actually matter? Because if we only care about relative concentrations of ^{10}Be then I think this strengthens your argument that this technique is reproducible.

Good Luck with the paper.

Martin

Paper: 'Tracking fluvial sand through the Waipaoa River Basin, New Zealand, using meteoric ^{10}Be' by Lucas J. Reusser, Paul R. Bierman

Reviewer: Nikos Fytilis – 03/31/09

The purpose of this paper is to present a new method by which someone can identify sources of fluvial sediment and track that sediment downstream measuring concentrations of meteoric ^{10}Be. The area under study is located in the Waipaoa River Basin in the northeast coast of New Zealand's North Island. Rapid erosion is observed in this basin due to human activities (land-clearance, agricultural) and even though the erosion in the Waipaoa River Basin has been studied extensively, the goal of this manuscript was to monitor the sediments in all prominent tributaries contributing to the mainstem. The samples collected were analyzed using cosmogenic techniques and the results showed that meteoric ^{10}Be is a valuable tool for land management. In addition, it is clear from further analyses that for the mainstem there is temporal homogeneity of meteoric ^{10}Be concentrations. Since the results could be fast and reproducible, the dynamics of fluvial sediment network within watersheds could be fully and accurately understood with meteoric ^{10}Be concentrations.

My general impression of this manuscript is that the work you have done and the way you present it here is all very solid. I recommend this paper be accepted with minor revisions. This was a very good paper even though that for the most part was hard to read from someone who knows very little about the subject, like me for example. At the end I was able to understand the author's intensions by means of the results provided. The only thing that really bothers me is the limit for four printed pages which all articles should have in order to be accepted in the Geology journal. The only sections I think you are able to short them is the abstract (don't mention all the results or summarize more the following lines: 52-57) and the Waipaoa River Basin section where you could extract information and included it in the figures. You should check also how many words you have in each page because you could satisfy the criteria for one Geology page. Overall, I thought your abstract was well written and clear and made the case for the utility of this method well. Also, the manuscript's contribution is significant.

Primarily, I want to clarify and focus on some specific questions/recommendations/comments which are listed below:

- I couldn't find what do the concentration units (at/g) stand for? You used them in the abstract and I am not sure if there are SI units or English units?
- Due to the limitation in pages you have, I believe you didn't fully describe the logic steps you followed to get to your results.
- This method is applicable in any catchment size or degree of erosion?
- You checked the reproducibility of your method but in a short time of period. It would be better to check it in a longer time period.
- In the Figure 1 which is excellent, you could make the arrows labeled "Rep" bigger.
- In the Figure 2, since you use again black dots and triangles, you should add them to the legend.
- In the Figure 4, I couldn't understand the flags at the top part of the plot. What do they represent?

Please refer to the hard-copy edited version of the manuscript for small comments regarding structure and some spelling errors.Good luck with edits and publication. Well done!

Tracking fluvial sand through the Waipaoa River Basin, New Zealand, using meteoric ^{10}Be.
By Lucas J. Reusser, Paul R. Bierman

04/01/09
Review by Christina Syrrakou

This paper presents the use of meteoric ^{10}Be in order to identify sediment sources and monitor the mixing of the sediments in the route travelled from headwaters to the sea. The area under study is the Waipaoa River Basin in New Zealand which is an area influenced in a great degree from human activities and together with the complex geologic environment presents great interest in the study of sedimentation processes. The method used is fairly new and in the end the writers conclude that it is not only a very rapid and quite easy method to use but also temporally reproducible.

The manuscript is quite well-written. It is obvious that the writers tried to keep the content small, avoiding much detail. Generally it is easy to follow but there are a few parts where the use of technical terms makes it more difficult to follow for a non-expert especially at the last part of the paper. However, considering the journal under target the language can be considered suitable.

So, considering the quality of the text together with the new method used and the results which strengthen the value of this method I recommend that this paper is published with minor revisions which are the following.

At the abstract, I would like to see at the very beginning some kind of introductory phrase stating that this is a new method. Also, at the end of the abstract I think that the fact that this method is reproducible can be added since it is a very strong point of the paper.

At the introduction, the first part focuses a lot on the impact of the human activities in sedimentation processes which for me is not the main focus of this paper, although a strong characteristic of the region under study. I think that the info contained in this paragraph would be more suitable to the "Waipaoa River Basin" part. A good point of this section however is that it emphasizes on the advantages of the specific method compared to the *in situ* method that is usually used.

At the "Waipaoa River Basin" section, (l14-144) it is stated that it remains uncertain which proportion of sediments is derived from the northern headwater vs. the stable eastern and western portions of the basin. Does this mean that it is not clear whether the sedimentation is affected more by human behavior or natural environment?

As far as the "Methods" part, at the second paragraph it is stated that the analysis took place at three Universities. However, it is not very clear to me whether this happened to check the reproducibility of the method or for other reasons.

As mentioned earlier, the "Meteoric ^{10}Be as a useful tracer of fluvial sediment sources" was a bit hard for me to follow due to the geological background needed. However, phrases as "This finding implies that nearly half of the sediment leaving the Waipaoa system…" which summarize the results were very helpful.

As for the final section of the paper, that is "Implications and Future Research", I think that it summarized well all the main concepts of the paper. As a reader though, I

would like to see a more direct conclusion on whether this method indicated the extent of the human activities' impact versus the natural environment.

The figures were well presented and I think that especially Figure 3 can be very helpful to the readers since it provides a straight-forward visual presentation of the different parts of the area under study. However, as for Figure 4, it was not very clear to me which is the direction downstream. Is it left to right or right to left?

In conclusion, I believe that the quality of the paper is strong and some clarifications would make it even better. I hope I was of help.. Good luck!

Tracking fluvial sand through the Waipaoa River Basin, New Zealand, using meteoric 10Be

Reusser and Bierman

Review by Andrea Pearce
3/31/09

Reusser & Bierman present a method for using 10Be to track the relative erosion rates throughout a rapidly eroding basin in New Zealand. They content that the sand in the river should be well enough mixed to represent an average of the upstream gully erosion. Fluvial sand was collected and processed and analyzed via crazy isotopic techniques to yield a 10Be concentration. There is a very nice relationship between the drainage area and 10Be concentration throughout the watershed. The authors suggest that a technique such as this could be used to help identify which sub basins in a watershed are the greatest contributors of sediment downstream.

This manuscript is well written, clear and concise. They are well thought out, informative and look pretty slick. The overall organization of the paper is logical and effectively guides the reader through. The test basin is reported to be eroding rapidly and I'm curious how well resolved differences in 10Be would be in a more slowly eroding basin.

This manuscript presents a new method and seems well suited to the goals of Geology and is worthy of publication at this journal. I recommend it be accepted with minor revisions. Minor editorial notes are included in the attached copy of the manuscript and more significant comments follow:

- Lines 241-246 – This sentence is long hard to follow. Try breaking up into two sentences.

- General Comment: I'm not entirely sure I understand how it's all working, but it seems like the 10Be measurements represent relative erosion rates within the contiguous catchments. You say that this could be used as a diagnostic tool in other watersheds. Are significantly slower erosion rates going to reduce 10 Be concentrations? Will measurement error overshadow the signal you're trying to pick up?

Afraid I'm not too much help with this one. Overall this looks great.

Review of

Tracking fluvial sand through the Waipaoa River Basin, New Zealand, using meteoric ^{10}Be

Luke Reusser

This paper looks at the use of meteoric ^{10}Be to determine where sediment is generated in the Waipaoa River Basin in New Zealand and the rate at which it is being generated. Another main reason this research has been done is to look at the validity of using meteoric ^{10}Be to look at sediment generation in basins that in situ ^{10}Be is not available. The research shows that meteoric ^{10}Be is a viable alternative to in situ ^{10}Be and that it can roughly determine the source of the sediment and how much is being generated. (Hopefully my research will help confirm the validity of meteoric ^{10}Be.) Ultimately these findings can allow land managers to better combat erosion by know where the erosion is the worst.

The paper as a whole is a well done and well explained paper. The data in this paper is present in an easy to understand way and seems to be of the highest quality. The interpretations make sense and were what I expected. There is more then enough information here to publish but I think future studies on this subject in other places is very important. The writing is clear and easy to understand, it just needs some cleaning up. I really like the figures, I think they, with the captions could practically stand on their own for a paper.

I strongly recommend this paper for publication, but it does need minor revision and some more referencing. I think the information is new, interesting and can be applied for practical uses. I few thing that need to be fixed or expanded are;

1. The abstract starts off to suddenly.
2. Basic writing needs to be cleaned up.

3. References and citations need to be finished.
4. Figures need to be correctly referenced in the paper.
5. I think the implications and future research section could be expanded. I think it could quickly state how little research has been done like this, current research that is being done to look at meteoric and what else you suggest should be done.

Charles Trodick

Eric Portenga
4/1/09

Review for Reusser and Bierman

Reusser and Bierman apply a new method of using atmospheric-produced ^{10}Be to determine downwearing rates in a New Zealand river catchment to trace sediment back to their parent lithology and trace sediment mixing. The study area has been logged intensively and the natural processes have been extremely thrown off kilter by human interactions with the landscape. Most ^{10}Be studies rely on *in situ* concentrations of the isotope, but in this study, the atmospheric component is utilized which makes their method applicable for use in many basins because it does not rely on the basin's lithology. This study concluded that using atmospheric ^{10}Be is a viable method for obtaining reproducible and meaningful data in basins where similar cosmogenic methods would not work which will be usable for land managers.

The methods used in this paper are what make it unique in that they present a new ^{10}Be sampling method for areas that otherwise would not have been sampled in that it does not rely on basin lithology. I understand the general basin-scale ^{10}Be approach to landscape change studies, but am not well versed so I did have some questions about the study as to what the data actually shows. The paper was very well written and I look forward to understanding more about this study and its applications for future cosmogenic studies.

Because a new method is presented that makes the number of usable sampling areas larger for cosmogenic studies, it is important that this paper be published so that all wrinkles are ironed out with feedback from the scientific community quickly so the methods will be usable for land managers.

- There were some parts of the paper that could have been phrased better such as lines 49-52, 85-87, 110-113, and 268-269. I made more detailed comments in the margins, but essentially these were areas I had to re-read through a few times to fully get at what you were saying.
- I also made note of a number of places where terms or notations of values and units were not consistent for better readability of the manuscript.
- I had concerns about the methods, that I am sure will be answered but here are a couple:
    - Does atmospheric ^{10}Be get picked up as the grains are being transported and is it enough to alter the results?
    - The lithology is basic so it helps buffer acidic solutions which would release atm ^{10}Be from the sediment grains, but can the grains accumulate more atm ^{10}Be from the water as it is being transported?

I enjoyed reading this paper because it is methodologically related to my own studies and I look forward to discussing it more in depth.

Review of

Tracking fluvial sand through the Waipaoa River Basin, New Zealand, using meteoric ^{10}Be

Luke Reusser

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Charles Trodick