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Solid Earth Discussions



# *Interactive comment on* "Use of rare earth oxides as tracers to identify sediment source areas for agricultural hillslopes" *by* C. Deasy and J. N. Quinton

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The manuscript presents a relevant work in a very active field in the last years, a topic of interest to most the scientist working in sediment tracking at field scale. It has been made with a sounded scientific approach and the results are relevant. That is why, in my opinion, this manuscript should be accepted for publication. However there are some issues that although could probably not been completely solved within the scope of the work presented in the manuscript, given the relative novelty of the technique, should be given more space in the manuscript.

We thank the reviewer for their support of the manuscript and welcome their sugges-



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tions.

I have two main general comments.

The first goes in the line of the limited statistical significance of differences based on the results presented in the manuscript (especially those in Figure 2). I am not sure if that is the result of averaging the results of the four plots or represents a relatively large variability in the analytical results coming from the sediment collected at each of the four plots. Including more information about the methods and results on the analytical results of RRE in sediment would benefit the manuscript and the discussion.

The variability shown in the results is due to differences in the erosion rates between the four different hillslope areas monitored, and between the storms monitored. The analytical results were produced using standard QC procedures in an accredited laboratory. We need further information on which results the reviewer feels it would be helpful to include.

2- My second comment goes in line with the previous one. It is apparent from the low depletion rates (between 0.01 and o.15 % per event approximately) that the concentrations for a given RRE element in the sediment might be very small. I have to apologize but I have not been able to perform the back calculations myself from the information in the manuscript and the supplemental material. The manuscript could gain providing the actual concentration of the different RRE measured in the sediment, their variability and the implications for future sampling and analysis.

The concentrations of REE in the sediments can be given in an additional table in the Supplementary Material section (as below), if required. These are generally high, and well above limits of detection, if this is the reviewer's concern. Background concentrations, as shown in figure 1 are 3.8 mg/kg for Gd, 6.0 mg/kg for Pr, 5.1 mg/kg for Sm, and 24.5 mg/kg for Gd.

Eroded concentrations for each element for tagged plots (mg/kg) Upslope Midslope



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Downslope Wheel Track Event Gd Pr Sm Nd Event I 667.7 90.84 24.49 5346 Event II 130.9 29.69 7.76 1186 Event III 145.1 17.71 8.57 1076 Figures are average of all 4 hillslope lengths used for the experiment. N.B. the contributing area for the wheel tracks is around three times greater than for the other hillslope segments.

Other comments of minor relevance that might help the authors to improve the manuscript are:

1- Ventura el al. published a further paper (Ventura el al., 2002. catena 48: 149-161) in which they mentioned as a major limitation the preferential sorting of their tracer compared to the soils, and also that the ratio tracer: sediment in runoff did not remain constant under different rainfall intensities. This would probably been worth mentioning in the introduction.

We thank the reviewer for the reminder, and agree that it would be appropriate to mention this in the introduction.

2- Figure 2 is really difficult to read with error bars overlapping. I would suggest presenting these results in a format similar to that of Figure 4 in Stevens and Quinton 2008 (Catena 74: 31-36) and also including a Table with the individual results per plot. This might facilitate understanding by the reader and discussion.

We prefer the original figure as it shows the total depletion rate for each hillslope area. However, we can present the figure as you suggest (shown in revised figure attached), or we can also include a table with the individual results per plot, but this may not be necessary if this revised figure is used.

% Depletion rate for each element Event Upslope Midslope Downslope Wheel Track Total Event Gd Pr Sm Nd Event I 0.162± 0.244 0.012± 0.015 0.004± 0.004 0.064± 0.083 0.311 Event II 0.123±0.148 0.019±0.020 0.006±0.005 0.069±0.084 0.033 Event III 0.014±0.008 0.001±0.001 0.001±0.000 0.006±0.004 0.283 Values are averages for four hillslope areas, with standard deviations.



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3- The authors assume in the manuscript homogeneous tagging of the soil in the top 1 cm of the soil based on the results of Stevens and Quinton (2008). However it is apparent from Figure 3 of these authors that concentration of RRE decreases in soil from surface (0 cm depth) to 0.5 cm depth. It will be interesting to address this issue, and also the potential differences in distribution based on the two different methods of application of the RRE (between Stevens and Quinton 2008 and those in the revised manuscript).

Stevens and Quinton showed that concentrations of REO decrease to background levels in the laboratory by 4 cm depth, and that the majority of the REO is held in the top 0.5 cm of the soil. However, for Nd, there is still a significant proportion held in the soil between 0.5 and 1.5 cm depth. We decided to compromise on a 1 cm depth of interaction for spray application. In addition, the depth of interaction is an approximation as these leaching experiments were not undertaken in the field, but in the laboratory where it is easier to control conditions and soil topography is different.

4- Zhang et al. 2003 (SSSAJ 67: 279-288) determined the extraction efficiency of the RRE used, using this recovery rates in their calculations. These recovery rates varied between 88 and 110% for the elements used in this manuscript. It will be useful to other authors to include in materials and methods this recovery rate for the procedure used.

The recovery rates of the adapted USEPA REE extraction used are discussed in the forthcoming paper (Pryce and Quinton, in prep), and in Pryce's PhD thesis. We can reference this in the methods section if required. We wished to focus on the application method of tracers at hillslope scale, rather than method development, as this has already been covered by our colleague, and this study builds on the methods which Pryce has spent three years developing in the laboratory.

5- It is apparent that deposition of detached sediment had to be very small. However I wonder if the authors might considered useful in the context of their study to comple-



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ment sediment analysis with analysis of soil samples taken after the rainfall period (or periods) to keep track of the sediment moving along the slope as done, for instance, by Polyakov et al. 2004, Earth Surf Proc Land 29: 1275-1291.

We did indeed undertake this analysis, but the variability in this data was very high and as a result difficult to interpret. We considered that it was best to present the data collected from the tanks at the base of the hillslope in this paper together with the spraying method, and not to complicate the story with the results of a second sampling strategy.

6- Inclusion of the dimensions of each area in Figure 1 might be helpful, also specific indication in the manuscript of there were some traffic in the plots during the experiments. Also if ground cover was similar in the differently tagged areas during the experiments.

The collection tanks were 1.5 m wide. We can add this information to the figure, but please note that it is already included in the methods section. We assumed that the contributing area to each tank for each hillslope segment was 1.5 m minus the width of the tramline (0.75 m), multiplied by the length of the hillslope segment (23 m for the ploughed area and 33 m for the minimum tillage area). We can add these dimensions to the figure. We did not limit traffic in the plots during the experiment, as this was undertaken as part of a wider mitigation trial where we asked the farmers to treat the field as they normally would. However, any trafficking would have been undertaken in the same way in each hillslope area. There was no difference in ground cover over the hillslope, as supported by no difference in yields observed at harvest time between the different treatments.

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Interactive comment on Solid Earth Discuss., 2, 195, 2010.





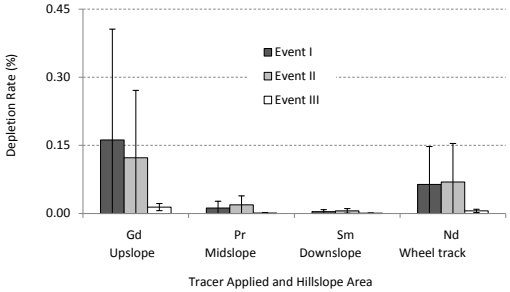


**Fig. 1.** FIGURE 2. Depletion rates of applied rare earth tracers for three events monitored at Loddington between 156 January and April 2008 after tagging of four hillslope areas.



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