

## The effects of fluvial transport on radionuclide concentrations on different particle size classes.

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### Introduction

This paper reports on the effects of grain abrasion and disaggregation on the distribution of <sup>137</sup>Cs with respect to particle size and the effects this may have on the use of <sup>137</sup>Cs for determining the origin of recent sediment. Cs-137 is a product of above ground nuclear testing and has been deposited on the earth's surface by rainfall. On contact with soil, <sup>137</sup>Cs is strongly adsorbed by soil particles (1, 2) and there is a direct correlation between <sup>137</sup>Cs concentration and decreasing particle size (3, 4, 5). Rapid adsorption means that <sup>137</sup>Cs is preferentially concentrated in surface soils (6), and its subsequent redistribution by physical processes rather than chemical (7) has led to <sup>137</sup>Cs being widely used to study soil erosion (for some examples see: 8, 9, 10, 11, 12).

The processes of erosion, transport, deposition and storage result in: selective transport and sorting on the basis of size, shape and density; abrasion and breakage; and chemical transformations. Sediment is the product of the simultaneous action of all of these processes. Many parameters used in tracing the movement of sediment, including <sup>137</sup>Cs, vary systematically with particle size (5, 13). The selective nature of erosion and transport means that sediment will be enriched in certain size fractions. Therefore, concentrations of the tracing parameter in the sediment are not directly comparable with those in source soils. This is well recognised and typically a narrow particle size window is compared to account for such size effects (10).

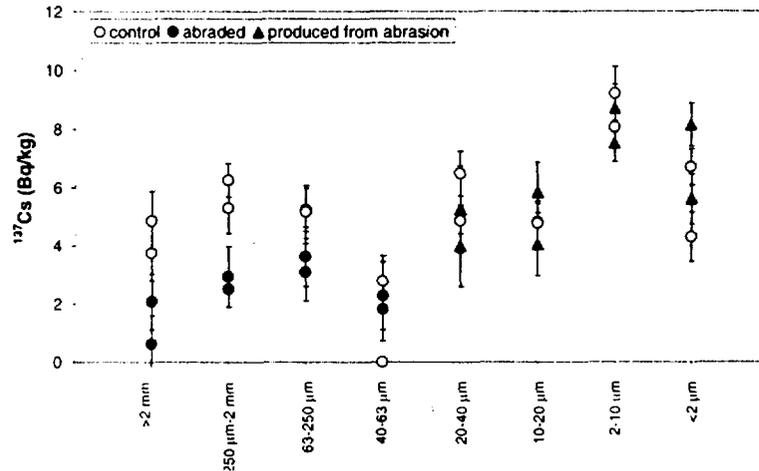
Abrasion and breakage act to remove surface coatings, break up aggregates, remove rough edges and cleave particles. While each of these processes has the potential to effect the concentration of parameter being used to trace sediment, there have been few studies of the effects of these processes on the signal being used to trace sediment. Olley studied the effects of grain abrasion on lithogenic radionuclide concentrations and ratios (14), and Crockford and Olley examined the effects of breakage and abrasion on the magnetic properties of sediment (15). In the current study the effects of grain abrasion on the concentration of <sup>137</sup>Cs on different sized particles derived from soils formed on three different rock types is examined. This is the first investigation of the effects of abrasion and disaggregation on the distribution of <sup>137</sup>Cs with respect to particle size.

### Methodology

Surface soil samples derived from basalt, granite and sedimentary parent rocks were collected from the Tarago catchment, south eastern Victoria, Australia. A sub-sample was separated into the following size classes: <2 µm, 2-10 µm, 10-20 µm, 20-40 µm, 40-63 µm, 63-250 µm, 250 µm-2.0 mm and >2.0 mm. These size fractions were analysed to determine the concentration of <sup>137</sup>Cs in each of the fractions prior to abrasion. Particles <40 µm in size are typically transported in suspension and consequently do not undergo

The increase between the coarsest and fine fractions is not as great as the increase observed in the granite derived soils.

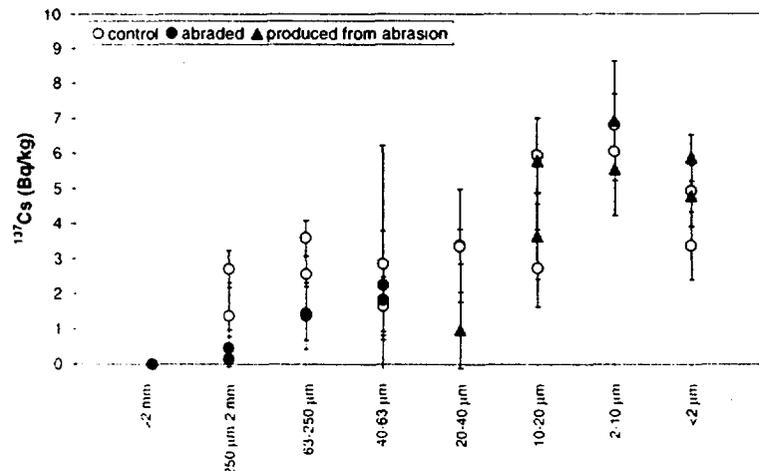
The  $^{137}\text{Cs}$  activity generally decreases with abrasion for particles larger than  $63\ \mu\text{m}$  and there is little change in the  $40\text{-}63\ \mu\text{m}$  fraction. The derived material has the same  $^{137}\text{Cs}$  activity as the corresponding size fractions of the control material. These changes are consistent with the removal of surface coatings from larger particles, the breaking of aggregates and the redistribution of this material, into the finer fractions.



**Figure 2.** The distribution of  $^{137}\text{Cs}$  with respect to particle size for the basalt derived soils

#### *Sedimentary Derived Soils*

The concentrations of  $^{137}\text{Cs}$  in the different size fractions from the sedimentary derived soils are given in Figure 3. Very little  $>2\ \text{mm}$  material was available for gamma analysis, illustrating the fine grained nature of these soils. As with the granite and basalt derived soils there is an increase in  $^{137}\text{Cs}$  concentration with decreasing size, peaking in the  $2\text{-}10\ \mu\text{m}$  fraction and the dropping slightly in the  $<2\ \mu\text{m}$  fraction. The concentrations of  $^{137}\text{Cs}$  are similar to those observed in the basalt derived soils reflecting the agricultural use of these soils.



**Figure 3.** The distribution of  $^{137}\text{Cs}$  with respect to particle size for the sedimentary derived soils

In most size fractions the changes due to abrasion are within the errors (one standard error on the mean) associated with the measurement of the  $^{137}\text{Cs}$  activity. However, there is a general decrease in  $^{137}\text{Cs}$  concentration with abrasion for particles greater than  $63\ \mu\text{m}$ . The derived particles have the same  $^{137}\text{Cs}$  activity as the corresponding size fractions in the control material, with the exception of the  $20\text{-}40\ \mu\text{m}$  fraction which displays a lower  $^{137}\text{Cs}$  activity than the corresponding size fraction of the control.

### Discussion

The primary action of abrasion of soils over a distance of 7.8 km appears to be aggregate breakage and the removal of surface coatings. There does not appear to be any significant change to the size and shape of the mineral grains. Thus, there is the removal of material for which  $^{137}\text{Cs}$  has an affinity from the larger size fractions and the redistribution of this material throughout the fine fractions. This is supported by a reduction in  $^{137}\text{Cs}$  concentration in the abraded material. Cs-137 concentrations in the material produced from abrasion and the corresponding size fractions in the original material are similar. In terms of the  $<40\ \mu\text{m}$  size fraction, which dominates the sediment in Tarago Reservoir, the  $^{137}\text{Cs}$  concentration on the  $<40\ \mu\text{m}$  sediment, which would include both material generated by grain abrasion and original soil material, will be the same as that on the  $<40\ \mu\text{m}$  fraction from soils (Table 2). Consequently, grain abrasion will not significant effect the results gained using  $^{137}\text{Cs}$  to determine the source of sediment to the Tarago reservoir.

**Table 2.**  $^{137}\text{Cs}$  concentrations and standard errors in the original  $<40\ \mu\text{m}$  material and in the material produced from abrasion

Sample	$^{137}\text{Cs}$ in original $<40\ \mu\text{m}$		$^{137}\text{Cs}$ in $<40\ \mu\text{m}$ material produced from abrasion(%)	
	Bq/kg	standard error	Bq/kg	standard error
Granite 1	20.6	0.9	18.5	0.9
Granite 2	18.5	0.6	17.6	0.5
Basalt 1	7.0	0.4	6.3	0.5
Basalt 2	5.6	0.3	6.9	0.4
Sedimentary 1	4.8	0.6	4.8	0.6
Sedimentary 2	4.1	0.4	5.4	0.6

### Conclusions

Whilst some changes in absolute  $^{137}\text{Cs}$  concentration occur as the result of abrasion over 7.8 km, this does not significantly change the concentration of the  $<40\ \mu\text{m}$  size fraction which dominates the sediment in Tarago Reservoir. There is also very little change to the pattern of  $^{137}\text{Cs}$  distribution with respect to particle size. The changes are the result of aggregate breakage and the removal of surface coatings from the larger particles and the redistribution of this material throughout the fine fractions. The material produced from abrasion has the same  $^{137}\text{Cs}$  concentration as the corresponding size fractions of unabraded material. These findings provide greater confidence in the use of  $^{137}\text{Cs}$  concentration in determining the sources of sediment in the Tarago catchment, and other studies in which  $^{137}\text{Cs}$  is being used to trace the origin of deposited sediment.

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