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Using meteoric ^{10}Be to track fluvial sand through the Waipaoa River Basin, New Zealand

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Sample preparation and measurement:

Upon arrival at the University of Vermont, we thoroughly dried each sample, then milled a well mixed ~20g aliquot in a SPEX Centriprep 8500 Shatterbox to a fine powder. We further prepared samples in three separate cosmogenic isotope laboratories located at the University of Vermont in Burlington, VT, the University of Washington in Seattle, WA, and Hebrew University in Jerusalem, IS. Meteoric ^{10}Be was isolated from a ~0.75 g aliquot through the rapid fusion method presented in Stone (1998), precipitated as a hydroxide, burned to produce BeO, packed into cathodes mixed with Nb power, and measured at the Center for Accelerator Mass Spectrometry (CAMS), Lawrence Livermore National Laboratory. We normalized measured ratios of ^{10}Be/^{9}Be to the 07KNSTD3110 standard (Nishiizumi *et al.*, 2007) to arrive at our final ^{10}Be concentrations.

Process and temporal replication:

We calculate the percent difference between process and temporal replicates by dividing the absolute difference between ^{10}Be concentrations of the two analyses by the average of the two analyses.

Mid-basin mixing model:

In order to quantify the proportion of sediment originating in the upper basin, which contains nearly all of the gully complexes in the Waipaoa system, versus the more stable eastern and western tributaries, we generated a simple mixing model using meteoric ^{10}Be concentrations:

$$[N_{up}][m_{up}] + [N_{trib}][m_{trib}] = [N_{down}][m_{up} + m_{trib}]$$

and

$$[m_{up}] + [m_{trib}] = 100\ \%$$

where $[N_{up}]$ is the meteoric ^{10}Be concentration measured in WA3met, upstream of the confluence of the eastern and western tributaries, $[N_{trib}]$ is the average meteoric ^{10}Be concentration measured in sediment from the eastern and western tributaries (WA15met

and WA2/23met), $[N_{down}]$ is the average ^{10}Be concentration measured in WA1/21met, downstream of the confluence of the tributaries, $[m_{up}]$ is the percent of total mass delivered from upstream, $[m_{trib}]$ is the percent of total mass contributed by the two incoming tributaries, and $[m_{up} + m_{trib}]$ is the total mass at the downstream mainstem sample site. Refer to Fig. DR-1 and Table DR-1 for sample locations and concentrations.

The model suggests that, at this prominent tributary confluence, ~95% of the sediment originates upstream, from the gully-impacted landscape. Because the area upstream of the confluence (765 km^2) and the area represented by the incoming tributaries (717 km^2) are roughly equal, this suggests that the northern Waipaoa basin is producing sediment at a proportional rate approximately 20 times greater relative to the more stable eastern and western tributaries.

In Table DR-1, note that for this mixing scenario, the combined areas of WA3met, WA15met and WA2/23met (1482 km^2) do not exactly match the "mixed" area at WA1/21met (1560 km^2). This discrepancy is due to the fact that we collected samples a sufficient distance from the actual confluence in order to ensure that no backwater mixing of sediment occurred during extreme discharge events.

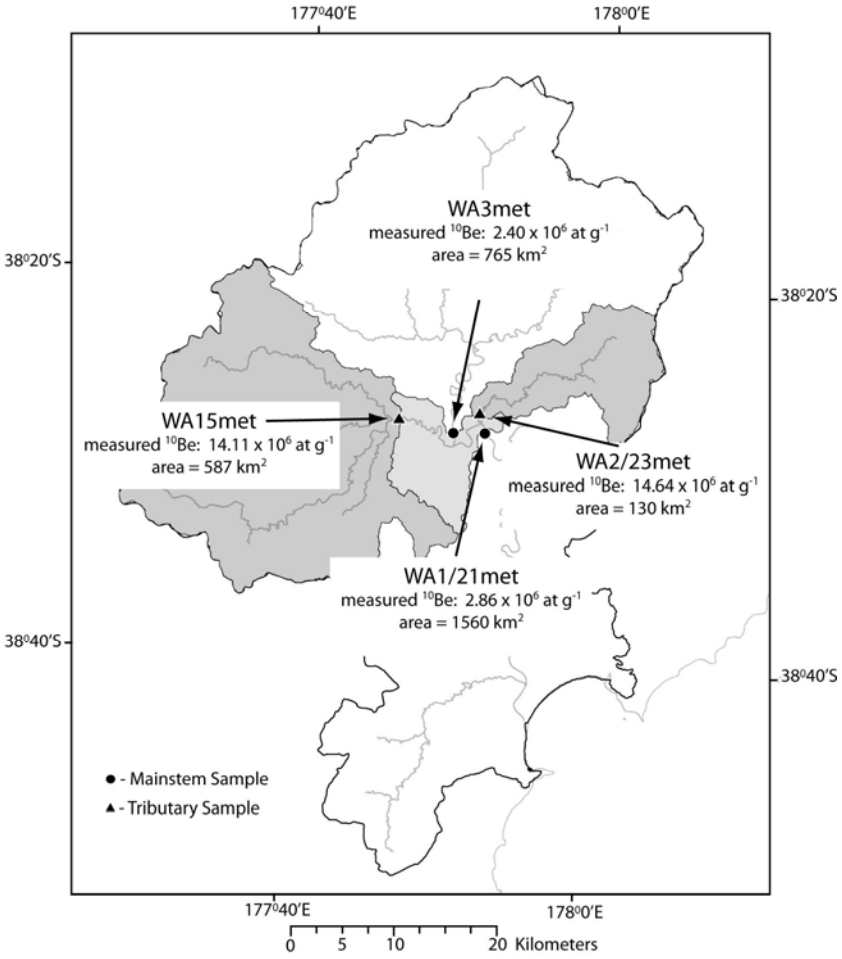

Figure DR-1: Map depicts the four samples used in the mixing model used to determine proportionally how much sediment originates in the northern headwater regions of the Waipaoa basin, vs. the eastern and western regions of the basin.

Table DR-1. Summary information for all samples

Sample ID*	Collection Date	Type†	Basin	Dominant Lithologies§	Basin Area (km^2)	Area After Mix (km^2)#	Gully-prone Area (km^2)**	Percent Gully-prone Area	Easting††	Northing††	^{10}Be (at/g x 10^6)§§	Percent Analytic Error (±)	Laboratory Percent Difference	Temporal Percent Difference
wa55metis	March 2005	Mainstem	Waipaoa	Mix	135	-	62.7	46.6	2934482	6313167	1.68 ± 0.07	4.1	-	-
wa17metis	March 2005	Mainstem	Waipaoa	Mix	215	-	66.3	30.8	2932852	6307866	1.66 ± 0.07	4.4	-	-
wa8metis	May 2004	Mainstem	Waipaoa	Mix	237	-	66.3	28.0	2931309	6303207	1.52 ± 0.07	4.4	-	-
wa19metis	March 2005	Mainstem	Waipaoa	Mix	237	-	66.3	28.0	2931320	6303196	1.44 ± 0.06	4.1	-	-
wa8/19met_ave##	na	Mainstem	Waipaoa	Mix	237	-	66.3	28.0	2931315	6303202	1.48 ± 0.06	4.2	-	2.7
wa7metis	May 2004	Mainstem	Waipaoa	Mix	476	-	92.6	19.5	2933052	6302712	2.31 ± 0.08	3.5	-	-
wa14metis	May 2004	Mainstem	Waipaoa	Mix	692	-	119.4	17.2	2933907	6299582	2.40 ± 0.08	3.5	-	-
wa3metis	May 2004	Mainstem	Waipaoa	Mix	765	-	125.2	16.4	2932576	6292861	2.40 ± 0.09	3.6	-	-
wa4metis	May 2004	Mainstem	Waipaoa	Mix	1422	-	133.3	9.4	2934089	6292248	2.77 ± 0.09	3.4	-	-
wa1metis	May 2004	Mainstem	Waipaoa	Mix	1560	-	133.3	8.5	2935404	6293113	2.89 ± 0.10	3.4	-	-
wa21metis	March 2005	Mainstem	Waipaoa	Mix	1560	-	133.3	8.5	2935397	6293012	2.83 ± 0.10	3.4	-	-
wa1/21met_ave	na	Mainstem	Waipaoa	Mix	1560	-	133.3	8.5	2935401	6293063	2.86 ± 0.10	3.4	-	1.2
wa11metuw	May 2004	Mainstem	Waipaoa	Mix	1682	-	133.3	7.9	2937417	6286506	3.43 ± 0.11	3.1	-	-
wa10metis	May 2004	Mainstem	Waipaoa	Mix	1777	-	133.3	7.5	2937490	6275586	3.53 ± 0.13	3.8	-	-
wa53metuw	March 2005	Prom Trib	Tikihore	Gullied ss	18	18	14	79.1	2935834	6320513	5.65 ± 0.17	3.1	-	-
wa54metis	March 2005	Prom Trib	Waimatau	Gullied ss	15	33	11.7	76.0	2938264	6322674	3.28 ± 0.10	3.0	-	-
wa54metvt	March 2005	Prom Trib	Waimatau	Gullied ss	15	33	11.7	76.0	2938264	6322674	3.14 ± 0.18	5.8	-	-
wa54met_ave	March 2005	Prom Trib	Waimatau	Gullied ss	15	33	11.7	76.0	2938264	6322674	3.21 ± 0.14	4.4	2.2	-
wa52metuw	March 2005	Prom Trib	Te Weraroa	Gullied ms	29	62	12.6	43.2	2934448	6315280	1.62 ± 0.05	3.3	-	-
wa67metis	March 2005	Prom Trib	Mongoarongo	Gullied ms, ss, mel	38	100	1.1	2.9	2935332	6312973	1.86 ± 0.07	3.6	-	-
wa9metis	May 2004	Prom Trib	Mangatu	Gullied ms, lm	220	451	26.4	12.0	2931396	6302380	3.34 ± 0.14	4.1	-	-
wa6metis	May 2004	Prom Trib	Waingaromia	Gullied ms	194	667	26.9	13.9	2934984	6301871	2.51 ± 0.09	3.7	-	-
wa15metuw	May 2004	Prom Trib	Waikohu	Ungullied ms, ss	587	1397	7.4	1.3	2927098	6294320	14.72 ± 0.45	3.0	-	-
wa15metvt	May 2004	Prom Trib	Waikohu	Ungullied ms, ss	587	1397	7.4	1.3	2927098	6294320	13.50 ± 0.45	3.3	-	-
wa15met_ave	May 2004	Prom Trib	Waikohu	Ungullied ms, ss	587	1397	7.4	1.3	2927098	6294320	14.11 ± 0.45	3.2	4.3	-
wa2metuw	May 2004	Prom Trib	Waihora	Ungullied ms	130	1535	0	0.0	2935145	6294576	12.01 ± 0.37	3.1	-	-
wa2metvt	May 2004	Prom Trib	Waihora	Ungullied ms	130	1535	0	0.0	2935145	6294576	11.70 ± 0.37	3.2	-	-
wa2met_ave	May 2004	Prom Trib	Waihora	Ungullied ms	130	1535	0	0.0	2935145	6294576	11.85 ± 0.37	3.1	1.3	-
wa23metis	March 2005	Prom Trib	Waihora	Ungullied ms	130	1535	0	0.0	2935145	6294576	17.43 ± 0.56	3.2	-	-
wa2/23met_ave	na	Prom Trib	Waihora	Ungullied ms	130	1535	0	0.0	2935145	6294576	14.64 ± 0.46	3.2	-	19.1

* The last two letters on sample IDs indicate the lab in which they were prepared; vt = University of Vermont, uw = University of Washington, and is = Hebrew University.

† Mainstem = samples collected along the mainstem Waipaoa channel. Prom trib = samples collected from prominent tributaries mixing into the mainstem Waipaoa channel.

§ Lithology abbreviations are as follows: ss = sandstone, ms = mudstone, lm = limestone, and mel = melange.

Area after mix is the total basin area after a given tributary has mixed with the mainstem channel.

** Gully-prone areas were calculated in ArcGIS® using the East Cape Terrain Geographic coverage (Team, 1994).

†† All coordinates are listed in NZ Grid, 1949.

§§ Errors in nuclide concentrations include propagated laboratory and measurement uncertainties. Measured ratios of 10/9 Be normailized to the new 07KNSTD3110 standard (Nishiizumi, et al., 2007).

IDs ending in "ave" are the average of the indicated process or temporal replicates.

Table DR-2. Soil profile from the Te Arai basin, SW Waipaoa Basin.

Sample ID*	Collection Date	Type	Basin	Depth (cm)	^{10}Be (at/g x 10^7)†	Percent Analytic Error (±)
MJNZ5met	March 2005	Soil Profile	Te Arai	10	10.81 ± 0.29	2.7
MJNZ6met	March 2005	Soil Profile	Te Arai	20	9.90 ± 0.26	2.6
MJNZ7met	March 2005	Soil Profile	Te Arai	40	5.65 ± 0.14	2.5
MJNZ8met	March 2005	Soil Profile	Te Arai	60	2.48 ± 0.09	3.5
MJNZ9met	March 2005	Soil Profile	Te Arai	80	2.28 ± 0.06	2.8
MJNZ10met	March 2005	Soil Profile	Te Arai	100	1.97 ± 0.06	3.2

* All samples prepared at the Hebrew University in Jerusalem, Israel, and measured at CAMS, LLNL.

† Errors in nuclide concentrations include propagated laboratory and measurement uncertainties.
Measured ratios of 10/9 Be normailized to the new 07KNSTD3110 standard (Nishiizumi, et al., 2007).

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