Humans are the most significant global geomorphological driving force of the 21st Century

Anthony H Cooper, Teresa J Brown, Simon J Price, Jonathan R Ford and Colin N Waters

Supplementary Information

The data used to calculate the figures in the paper are contained within Table 1. Some of the data in these columns are themselves calculated figures. Additional notes relating to these calculations are provided below.

Mineral production statistics and overburden/waste

By using the world mineral statistics compiled by the British Geological Survey (BGS) since 1913 (British Geological Survey, 1913–2017) it is possible to make an approximate estimate of the amount of ground worked in order to produce the total world mineral output. To do this it is necessary to determine not only the mineral output, but also the waste factor (or overburden moved factor) for each mineral. For certain minerals, including coal, there will be different waste/overburden values depending on whether the coal has been deep (underground) mined or opencast (surface) mined. These values also vary between countries and over time.

The figures for mineral output must be used with caution. There are many factors that have changed the way that different minerals have been worked over time and the amount of waste or overburden associated with different working techniques vary. For example, coal mining was originally mined from bell pits, it then progressed to pillar and stall mines through to longwall mechanised mine extraction. Similarly, opencast mining has moved from digging at the outcrop using hand tools, to steam shovels and then to draglines and bucket excavators that have permitted larger and larger amounts of overburden to be removed.

In parallel with changes in mining techniques, there have also been changes in the way minerals (especially metals) have been extracted from their ores so that smaller percentages of extractable mineral have become economic to work, depending on the market price. Taking copper as an example, early mines in the early 1800s extracted vein material with an average copper content of around 9%, by the early 1900s 2.5% copper was economic to work and now mines exploit disseminated copper with as little as 0.77% of the metal (Crowson, 2011).

To understand the amount of mineral extraction and waste/overburden moved it is necessary to make some assumptions and generalisations, but with care a general figure for the amount of material moved can be calculated.

Coal and iron ore are the main excavated minerals comprising approximately 56% of the world mineral output in 2015. Crude petroleum and natural gas accounted for another 37% so these four commodities account for 93% of world output. All the other minerals amount to about 7% of world output (**Figure 1**). To facilitate the calculation of the mineral and waste/overburden figures key years have been chosen based on the graphical information for coal and iron ore. For these years, all the minerals have been included (except oil and gas because the majority of these two commodities are extracted from within pore spaces of geological formations, thus requiring little material to be moved and without generating much waste) and estimated the total amount of waste/overburden that would have been expected at the particular time interval. The key years taken are 1925, 1950, 1975, 2000, 2010 and 2015 (Table 2).

The proportion of waste material excavated compared to mineral recovered is known as the stripping ratio. These can be quoted in mineral output statistics as a volume:volume, a volume:tonnage, or a tonnage:tonnage figure and they also change over time. A wide range of literature sources were consulted to obtain the best available data for stripping ratios for coal (for example, see Štýs, 1987; Lubomir & Vaclav, 2007; Mining

Technology, 2017; Mohr et al, 2011; Anglo American, 2012; Whitehaven Coal, 2012; Averitt, 1974; Rusek et al, 1978; Grim & Hill, 1974; IMC, 1999; Gibson, 1981; Lawson et al, 2003; Chang-Sheng, 2008; Ikonnikov, 1977; Singh, 2005; Khoshoo, 2008; Kable Intelligence Ltd, 2017; Semirara Mining, 2016; Fikkers, 2013; Atrum Coal, 2013) and these were used to infer a global average for each year (**Figure 2a**). Volumes of overburden/waste were converted to tonnages using density figures available on the SI Metric website (SI Metric, 2016).

There has also been a significant shift over the last century from underground to surface coal mining, particularly in countries such as the UK, USA and Australia (**Figure 2b)**. However, due to a significant increase in the production of coal from China, from under 1 billion tonnes in 2000 to nearly 3.7 billion tonnes in 2015 (British Geological Survey, 1913–2017), and because more than 90% of the coal mined in China is still extracted from underground mines (Chang-Sheng, 2008), the inferred global average for the percentage of surface mined coal actually decreases after 2001. Again, a wide range of materials were consulted to obtain the best available data for the proportion split between surface and underground mining (for example, see Štẏs, 1987; Mohr et all, 2011; Averitt, 1974; Grim & Hill, 1974; Chang-Sheng, 2008; Khoshoo, 2008; Energy Information Agency, 2017; US Environmental Protection Agency, 1982; Fisher & James, 1955; Harris, 1995; British Geological Survey, 1973–2016; Harris et al, 2006–2010; Zhang et al, 2004; Moolman & Fourie, 2000; Irving & Tailakov, 1994; Mbendi, 2016; Thompson, 2005; Chikkatur, 2008; Sanhati, 2011; New World Resources, 2011; Tarazanov, 2012; Oddenino, 1993; Fuginski, 2012; Kazakh Research Institute, 2002). The change in mining method has to be factored into calculations of overburden/waste because a large quantity of overburden is moved at surface mines whereas much less waste is generated at underground coal mines.

For other minerals, stripping ratios vary by commodity and with 54 minerals, other than coal, included in the research these ratios were assessed at the key year intervals of 1925, 1950, 1975, 2000, 2010 and 2015. The amounts for other years were then inferred using the changes in coal as a proxy (**Figure 3**). For many minerals, stripping ratios were obtained from Douglas & Lawson, 2000, but other sources were also consulted and used where appropriate [for example, see Crowson, 2011; Sherlock, 1922; Müller & Frimmel, 2010; American Association for the Advancement of Science, 2001; World Bank Group, 1998; Johnson Matthey, 2016; Kogel et al, 2006; Symonds Group, 2001; Douglas & Lawson, 2002; Norgate & Haque, 2012; Shelton, 2013).

Aggregates and cement

The other minerals included above range from aluminium to zirconium, but do not include the extraction of construction aggregates or the materials used to manufacture cement (industrial limestone, clay and shale). However, aggregates and cement represent some of the largest amounts of materials moved by humans; in many countries they represent the largest material flow (Brown et al, 2011; Rogich et al, 2008). Global figures for the production of construction aggregates are not available but figures for Europe, the UK and the USA are published (Brown et al, 2016; Idoine et al, 2016; Bennet, 2016; Willett, 2016). The United States Geological Survey (USGS) also publish figures for worldwide production of cement, in addition to the production in the USA (van Oss, 2017), and the BGS publications include cement figures for the UK and several European countries (Brown et al, 2016; Idoine et al, 2016). Aggregates and cement are used in combination to produce concrete at reasonably fixed proportions but aggregates are also used without cement in products including road sub-base and ballast. The ratio between the production of cement and aggregates varies between countries due to factors including population density and the size of the country, but a typical global ratio can be inferred from the published data (**Figure S1**). This global ratio can then be applied to the published world cement manufacture figures to calculate an inferred series for worldwide aggregates production (**Figure 4**).

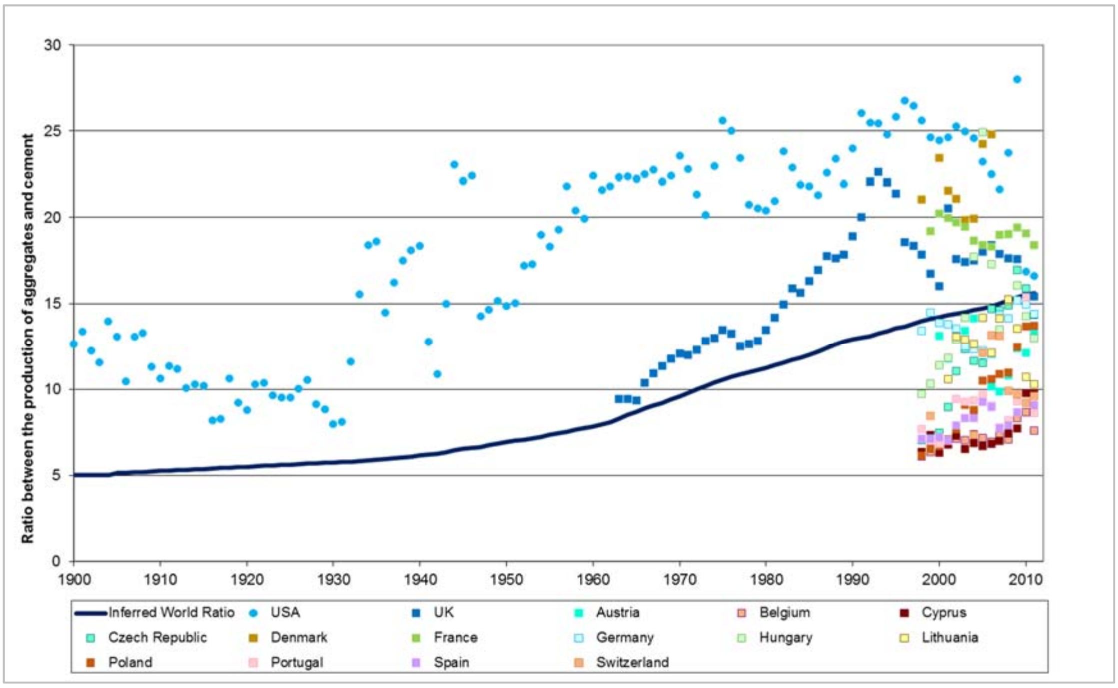

Figure S1. Production ratios between construction aggregates and cement, together with inferred world ratio.

Although the inferred world ratio on **Figure S1** appears to be below the individual data points for the years prior to 1998, this is an artefact of the availability of data. For all years prior to 1998 the country level data for the production of aggregates and cement are only available for the USA and UK and thus it is not possible to calculate the ratio for other countries. However, from 1998 onwards it can be seen that many countries have a ratio that is lower than both the USA and UK and hence the inferred world average is below that for the USA and UK.

Excavation during construction works

As noted in the main paper, the majority of construction works (e.g. buildings, roads, railways, tunnels, dams. docks, etc.) also require earthworks. These range from minor stripping of soil to major tunnelling and cutting and embankment construction. A detailed examination of a number of construction projects revealed a wide range of figures for the amounts of excavation required per tonne of cement and aggregates used. Calculations based on figures for 12 major roadbuilding schemes, across 10 countries, provided a multiplier of 21.5 times the estimated cement and aggregates used, whereas a similar calculation based on 6 major railway schemes in 6 countries resulted in a multiplier of 2.1 times and from 6 building projects (airport terminal, office buildings, dam, etc.) in 5 countries a multiplier of 1.7 times. For this research figures that are double the amount of global aggregates and cement production were used, but this is an area that would benefit from further work. Other sources of excavation and fill, such as unsurfaced gravel roads and mountain road or rail cuttings, have not been quantified.

Dredging

Dredging is carried out for a number of reasons including:

- the construction of new ports;
- the maintenance or deepening of existing ports and associated navigation channels;
- the protection of existing coastal infrastructure from sea level rise or tidal flooding;
- to increase flow capacity in rivers as part of a flood prevention strategy;
- the reclamation of land along a coast for building expansion; and
- to prepare the sea bed for maritime infrastructure such as pipelines or offshore wind turbines.

The extraction of aggregates from the sea floor has been excluded from this calculation to avoid double-counting. Dredging carried out for the extraction of fish and other sea-food is also excluded from the calculations but is estimated at 14.8 million km^2 per annum (Watling & Norse, 1998).

Global figures for the amounts of material moved during dredging operations are not published. However, estimates have been made based on the limited information that available. The International Association of Dredging Companies (IADC) has published annual figures for the turnover of the industry in recent years (IADC, 2017) and these can be converted to approximate cubic metres using figures for the typical cost per cubic metre moved in each year. The latter were derived from a number of sources [for example, see US Army Corps of Engineers, 2014; Sydney Coastal Councils, 2013; Owen & Park, 2009; Halcrow, 2009; Boskalis, 2017; Van Oord, 2012; National Marine Dredging Company, 2009; Gordon, 2013; Subsea World News, 2012; Middle East Dredging Company, 2008; United Nations Educational, Scientific and Cultural

Organisation, 1998). In some years the figures released by the IADC specifically do not include data for the USA and China and consequently these need to be added. Data for the USA is published by the US Army Corps of Engineers through their Navigation Data Center (US Armcy Corps of Engineers, 2017) and data for China have been compiled by Frost & Sullivan Consultants but are summarised in freely available reports (Hong Kong Exchanges and Clearing Ltd, 2011).

For the years prior to 2000, world totals for the amounts of material moved during dredging operations have been postulated based on the USA reported figures (US Army Corps of Engineers, 2017), interpolated USA figures for years missing in the reported series and the calculated world totals for 2000–2015 (**Figure 5**). USA figures were converted from cubic yards to cubic metres and all of the cubic metres figures were converted to metric tonnes using a density of 1.8 t/m^3.

Anthropogenic global sediment flux

The figure for anthropogenic global sediment flux of 316 Gt for 2015 was calculated by summing the results of the above calculations, which are in summary:

- World coal production (reported) with associated overburden and waste (calculated), adjusted for changes over time for stripping ratio and underground/surface working
- World production of metals and minerals other than coal (reported in key years, interpolated for the remainder) with associated overburden and waste (calculated)
- World cement production (reported)
- World aggregates production (estimated from a cement/aggregates ratio)
- Minimum quantity of material moved during the course of civil engineering earthworks related to construction (estimated based on cement and aggregates production)
- Material moved by World dredging operations (limited reported data with significant estimates to fill data gaps)

These figures are also quoted in the main paper in cubic kilometres, which are obtained by assuming an average density of 2.1 t/m^3. This is a higher figure than that mentioned earlier to convert dredged material to metric tonnes due to the wider range of materials involved.

An average density of 2.1 t/m^3 has been used as an approximation to enable the tonnages of material to be calculated as volumes. This figure is very approximate due to the large number of variables. These include the wide range of rock types, the ages of the rocks, the porosity of the rocks, whether the rock are wet or dry, the bulking factor when the materials were excavated and the compaction factor when they have been emplaced. Studies of rock density consulted include Manger (1963), Sharma (1997) and Ofoegbu et al (2008). Original densities range from as little as 1.25 t/m^3 for lignite, 1.35-1.55 t/m^3 for coal, 1.6-2.0 t/m^3 for sand and 1.5-2.0 t/m^3 for clay through 2.1-2.75 t/m^3 for shales, 1.63-2.7 t/m^3 for sandstone, 2.1-2.8 t/m^3 for limestone to the denser igneous rocks with 2.52-2.75 t/m^3 for granite and 2.8-3.1 t/m^3 for basalt. There is considerable variation in densities within each rock type depending on the age of the rocks, depth of burial (compaction) and cementation.

Once a rock is extracted there is also a considerable bulking factor that reduces the overall bulk density, this varies considerably depending on how the rock breaks up, it is also much lower for unconsolidated sedimentary rocks. Once extracted and re-deposited there is a further change in volume due to compaction, this can be a large reduction in mechanically compacted materials in civil engineering, or a low reduction in tipped materials. Bulking factors and final densities after deposition are tabulated by Ofoegbu et al (2008). Considering the large amount of variables, it is considered that a figure of 2.1 t/m^3 is a reasonable approximation for the density of average emplaced materials. However, a rigorous analysis has not been undertaken, this would require assigning individual figures to all the types of material excavated and emplaced. The 2.1 t/m^3 accords with the fill condition bulk densities given by Ofoegbu et al (2008).

As noted in the main paper, this figure for anthropogenic global sediment flux is many times larger than the natural sediment flux of the world's rivers. Humans are clearly the most significant annual sediment mover on the planet.

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Year	Annual World Coal Production (million tonnes)	Calculated overburden/ waste for coal (million tonnes)	Calculated World coal plus overburden/ waste surface and underground (million tonnes)	Calculated World mineral and metal production (excl. oil/gas) incl. waste/ overburden (million tonnes)	World cement manufacture (million tonnes) 1925 is estimated	Calculated World aggregates production [based on ratio to cement] (million tonnes)	Calculated world cement and aggregate production (million tonnes)	Calculated World civil engineering earthwork [assumed to be twice the aggregate and cement totals] (million tonnes)	Approximate World dredging tonnages (see supplemental information) (million tonnes)	Total mineral extraction, overburden/waste, cement, aggregates, civil engineering and dredging (million tonnes)	Calculated total annual volume of anthrop-ogenic sediment flux (km3)
1925	1 372	589	1 960	571	61	341	401	803	338	4 073	2
1926	1 362	603	1 965	585	62	353	415	830	378	4 173	2
1927	1 473	670	2 144	663	68	385	453	905	405	4 569	2
1928	1 463	684	2 147	688	72	412	484	967	486	4 772	2
1929	1 555	752	2 307	746	75	429	504	1 007	540	5 104	2
1930	1 412	709	2 121	692	72	416	488	976	594	4 871	2
1931	1 260	656	1 916	643	62	359	421	841	648	4 469	2
1932	1 128	623	1 750	586	49	286	335	670	759	4 102	2
1933	1 168	684	1 853	619	48	281	329	658	810	4 269	2
1934	1 280	795	2 075	704	58	341	399	799	1 078	5 055	2
1935	1 321	870	2 191	740	65	386	451	903	918	5 203	2
1936	1 443	1 009	2 451	822	63	374	436	873	918	5 501	3
1937	1 534	1 137	2 672	890	83	496	579	1 158	1 353	6 651	3
1938	1 443	1 134	2 576	866	86	520	606	1 211	1 057	6 316	3
1939	1 575	1 311	2 886	961	93	567	660	1 321	827	6 654	3
1940	1 687	1 539	3 226	1 063	81	498	579	1 158	1 167	7 193	3
1941	1 773	1 710	3 483	1 152	88	546	634	1 267	864	7 401	4
1942	1 784	1 818	3 602	1 178	81	506	587	1 173	731	7 270	3
1943	1 798	1 975	3 773	1 223	71	452	523	1 047	702	7 268	3
1944	1 727	2 037	3 764	1 209	55	354	409	818	739	6 939	3
1945	1 345	1 718	3 063	969	50	324	374	747	702	5 855	3
1946	1 468	2 025	3 493	1 101	73	479	551	1 102	667	6 914	3
1947	1 648	2 421	4 069	1 269	86	571	656	1 313	675	7 982	4
1948	1 695	2 646	4 341	1 339	102	689	791	1 581	661	8 712	4
1949	1 697	2 841	4 538	1 391	115	788	903	1 806	675	9 312	4
1950	1 821	3 226	5 047	1 555	133	924	1 057	2 115	702	10 476	5
1951	1 933	3 617	5 550	1 720	149	1 043	1 192	2 384	729	11 575	6
1952	1 930	3 853	5 784	1 776	161	1 135	1 296	2 592	756	12 204	6
1953	1 961	4 166	6 127	1 883	178	1 273	1 451	2 901	783	13 145	6
1954	1 971	4 402	6 373	1 971	195	1 413	1 608	3 216	810	13 978	7
1955	2 134	5 002	7 135	2 219	217	1 597	1 814	3 629	837	15 635	7
1956	2 256	5 602	7 858	2 436	235	1 754	1 989	3 978	864	17 125	8
1957	2 337	6 076	8 413	2 641	247	1 864	2 111	4 222	864	18 251	9
1958	2 439	6 629	9 068	2 877	263	2 008	2 271	4 541	864	19 621	9
1959	2 520	7 230	9 749	3 074	294	2 281	2 575	5 150	891	21 440	10
1960	2 632	7 958	10 589	3 342	317	2 485	2 801	5 602	918	23 253	11
1961	2 479	7 892	10 371	3 272	333	2 649	2 982	5 964	945	23 535	11

Year	Annual World Coal Production (million tonnes)	Calculated overburden/ waste for coal (million tonnes)	Calculated World coal plus overburden/ waste surface and underground (million tonnes)	Calculated World mineral and metal production (excl. oil/gas) incl. waste/ overburden (million tonnes)	World cement manufacture (million tonnes) 1925 is estimated	Calculated World aggregates production [based on ratio to cement] (million tonnes)	Calculated world cement and aggregate production (million tonnes)	Calculated World civil engineering earthwork [assumed to be twice the aggregate and cement totals] (million tonnes)	Approximate World dredging tonnages (see supplemental information) (million tonnes)	Total mineral extraction, overburden/waste, cement, aggregates, civil engineering and dredging (million tonnes)	Calculated total annual volume of anthrop-ogenic sediment flux (km3)
1962	2 550	8 536	11 086	3 494	359	2 904	3 262	6 525	972	25 339	12
1963	2 652	9 322	11 974	3 766	378	3 137	3 515	7 031	991	27 276	13
1964	2 753	10 154	12 907	4 048	416	3 533	3 948	7 896	844	29 644	14
1965	2 804	10 837	13 641	4 263	433	3 771	4 204	8 408	846	31 362	15
1966	2 835	11 469	14 304	4 451	464	4 131	4 596	9 191	846	33 387	16
1967	2 720	11 510	14 229	4 434	480	4 342	4 822	9 644	846	33 975	16
1968	2 745	12 139	14 884	4 612	515	4 740	5 255	10 510	846	36 108	17
1969	2 871	13 254	16 126	4 967	543	5 105	5 648	11 296	846	38 884	19
1970	2 944	14 175	17 119	5 211	572	5 489	6 061	12 122	846	41 359	20
1971	2 950	14 627	17 577	5 369	590	5 782	6 372	12 744	846	42 908	20
1972	3 041	15 522	18 563	5 687	661	6 610	7 271	14 542	846	46 908	22
1973	3 065	16 287	19 352	5 854	702	7 160	7 862	15 725	846	49 640	24
1974	3 107	16 980	20 087	6 090	703	7 313	8 016	16 033	846	51 072	24
1975	3 253	18 277	21 530	6 498	702	7 408	8 110	16 221	846	53 205	25
1976	3 349	19 228	22 577	6 832	735	7 906	8 641	17 282	846	56 178	27
1977	3 510	20 427	23 937	7 266	797	8 649	9 446	18 891	846	60 386	29
1978	3 558	20 963	24 521	7 507	853	9 383	10 236	20 472	846	63 583	30
1979	3 719	22 182	25 901	8 033	872	9 684	10 556	21 112	846	66 449	32
1980	3 806	22 928	26 734	8 335	883	9 935	10 818	21 636	846	68 369	33
1981	3 844	23 512	27 356	8 572	887	10 108	10 995	21 990	864	69 778	33
1982	3 996	24 811	28 807	9 071	887	10 249	11 137	22 274	873	72 162	34
1983	4 018	25 319	29 337	9 282	917	10 724	11 641	23 282	882	74 423	35
1984	4 231	27 052	31 283	9 901	941	11 152	12 093	24 186	891	78 354	37
1985	4 456	28 903	33 359	10 605	959	11 513	12 472	24 944	900	82 280	39
1986	4 567	30 044	34 611	11 006	1 008	12 298	13 306	26 611	918	86 453	41
1987	4 669	31 147	35 816	11 439	1 053	13 057	14 110	28 220	936	90 522	43
1988	4 783	32 128	36 911	11 910	1 118	14 087	15 205	30 410	954	95 389	45
1989	4 865	32 904	37 769	12 260	1 042	13 338	14 380	28 759	972	94 140	45
1990	4 711	32 298	37 009	12 060	1 043	13 455	14 498	28 995	990	93 552	45
1991	4 383	30 049	34 432	11 352	1 185	15 405	16 590	33 180	1 053	96 607	46
1992	4 509	32 039	36 548	11 859	1 123	14 711	15 834	31 669	1 080	96 990	46
1993	4 404	32 411	36 815	11 715	1 291	17 106	18 397	36 794	1 125	104 845	50
1994	4 516	34 398	38 914	12 147	1 370	18 358	19 728	39 456	1 170	111 415	53
1995	4 630	36 250	40 880	12 640	1 445	19 580	21 025	42 050	1 260	117 854	56
1996	4 699	37 415	42 115	12 970	1 493	20 379	21 872	43 745	1 350	122 052	58
1997	4 766	38 828	43 593	13 296	1 547	21 349	22 896	45 791	1 440	127 017	60
1998	4 602	38 743	43 345	12 978	1 540	21 560	23 100	46 200	1 530	127 153	61

Year	Annual World Coal Production (million tonnes)	Calculated overburden/ waste for coal (million tonnes)	Calculated World coal plus overburden/ waste surface and underground (million tonnes)	Calculated World mineral and metal production (excl. oil/gas) incl. waste/ overburden (million tonnes)	World cement manufacture (million tonnes) 1925 is estimated	Calculated World aggregates production [based on ratio to cement] (million tonnes)	Calculated world cement and aggregate production (million tonnes)	Calculated World civil engineering earthwork [assumed to be twice the aggregate and cement totals] (million tonnes)	Approximate World dredging tonnages (see supplemental information) (million tonnes)	Total mineral extraction, overburden/waste, cement, aggregates, civil engineering and dredging (million tonnes)	Calculated total annual volume of anthrop-ogenic sediment flux (km3)
1999	4 323	37 590	41 913	12 321	1 600	22 560	24 160	48 320	1 620	128 335	61
2000	4 310	38 679	42 989	12 423	1 660	23 572	25 232	50 464	1 861	132 969	63
2001	4 638	42 139	46 777	13 498	1 750	25 025	26 775	53 550	2 018	142 618	68
2002	4 815	43 847	48 662	14 108	1 850	26 640	28 490	56 980	2 176	150 416	72
2003	5 210	47 550	52 760	15 371	2 020	29 290	31 310	62 620	2 334	164 395	78
2004	5 711	52 217	57 928	16 962	2 190	31 974	34 164	68 328	2 491	179 874	86
2005	6 046	55 371	61 417	18 078	2 350	34 545	36 895	73 790	2 649	192 830	92
2006	6 345	57 597	63 942	19 034	2 620	38 907	41 527	83 054	2 589	210 146	100
2007	6 572	59 102	65 674	19 781	2 820	42 300	45 120	90 240	3 355	224 170	107
2008	6 815	60 680	67 494	20 512	2 850	43 235	46 085	92 169	3 769	230 029	110
2009	6 849	60 349	67 198	20 684	3 050	46 818	49 868	99 735	4 062	241 547	115
2010	7 153	62 324	69 476	22 587	3 290	50 995	54 285	108 570	4 259	259 177	123
2011	7 931	67 934	75 865	24 429	3 650	56 575	60 225	120 450	4 877	285 846	136
2012	8 201	69 012	77 214	25 752	3 820	59 592	63 412	126 824	5 826	299 029	142
2013	8 226	69 370	77 596	26 571	4 070	63 899	67 969	135 938	6 832	314 906	150
2014	8 165	68 702	76 867	27 270	4 180	65 626	69 806	139 612	8 086	321 640	153
2015	7 860	65 788	73 649	26 951	4 100	64 370	68 470	136 940	9 857	315 867	150

Table 1: Data used to calculate the global anthropogenic sediment flux (see paper and supplemental information for details of calculations and their implications); figures may not sum to totals due to rounding.

Year	1925	1950	1975	2000	2010	2015
Minerals/metals - shown as gross weight	Converted to metric tonnes, but shown unrounded		Metric tonnes, degrees of rounding differ by commodity and year			
Bauxite	1 412 305	84 331 901	77 000 000	139 157 577	228 000 000	294 000 000
Arsenic (white)	65 927	46 916	39 373	66 014	39 310	37 110
Asbestos	324 119	1 071 930	4 200 000	2 055 207	2 029 137	1 600 000
Barytes	490 737	1 351 343	5 200 000	6 009 764	9 100 000	7 900 000
Bentonite and fullers earth	189 667	366 054	6 542 000	15 741 258	18 500 000	21 700 000
Bromine	not available	46 486	277 546	543 551	650 000	569 000
Cadmium	461	5 806	15 700	19 423	23 300	24 900
Chromium ores and concentrates	314 975	2 341 988	8 400 000	14 676 586	27 800 000	35 300 000
Diatomite	117 680	446 488	1 400 000	1 609 834	1 777 000	2 374 000
Feldspar	410 358	782 356	2 870 000	13 049 778	22 236 000	26 150 000
Fluorspar	261 451	863 640	5 000 000	4 260 597	7 200 000	6 400 000
Graphite	121 926	131 070	442 000	2 031 555	2 100 000	2 200 000
Gypsum	10 465 284	20 930 568	59 000 000	97 331 379	146 900 000	268 200 000
Iodine	not available	not available	11 200	18 904	27 700	34 900
Kaolin	2 770 406	3 260 240	14 000 000	22 401 372	27 100 000	25 300 000
Lithium minerals	not available	18 027	118 000	222 822	653 720	576 095
Magnesite	775 458	9 550 842	9 500 000	20 141 895	37 500 000	44 900 000
Manganese ore	2 844 932	7 620 353	25 000 000	19 883 560	45 200 000	53 200 000
Mercury	3 629	4 808	8 800	1 436	2 100	2 400
Mica	21 998	86 872	209 000	327 295	348 000	810 000
Phosphate rock	8 839 609	22 881 378	109 000 000	132 476 901	182 000 000	265 000 000
Rare earth minerals	not available	508	38 800	80 708	105 520	154 036
Salt	23 369 081	45 417 301	162 000 000	210 240 580	279 300 000	289 600 000
Sillimanite minerals	not available	70 908	311 500	453 965	457 962	526 055
Talc	365 589	1 290 380	4 700 000	7 663 407	7 500 000	8 200 000
Tantalum and niobium minerals	not available	2 195	20 000	72 127	251 000	377 000
Titanium minerals	14 930	905 298	3 236 000	10 039 474	10 800 000	10 300 000
Zirconium minerals	not available	47 146	553 000	1 003 625	1 391 561	1 341 000
Beryl	not available	6 198	3 050	5 465	3 547	5 742
Borates	166 632	602 582	2 298 000	4 687 174	5 231 464	6 039 020

Nepheline syenite	not available	not available	669 000	1 865 000	5 808 000	6 007 900
Perlite	not available	not available	911 000	2 984 014	3 318 083	3 609 401
Strontium minerals	1 902	8 645	41 000	353 434	857 065	539 610
Vermiculite	not available	232 095	521 000	517 903	519 828	433 393
Wollastonite	not available	not available	61 000	727 673	1 025 029	1 338 427
Natural sodium carbonate	not available	not available	not available	10 636 070	12 941 825	14 099 076
Diamond	1	3	8	22	25	25
Potash (K_2O content)	1 295 482	3 304 800	14 880 000	16 133 815	18 000 000	22 740 000
Metals - shown as tonnes metal content	**Converted to metric tonnes, but shown unrounded**		**Metric tonnes, degrees of rounding differ by commodity and year**			
Antimony	28 449	45 519	72 100	118 060	163 000	143 000
Bismuth	574	920	4 300	4 217	3 300	4 300
Cobalt	814	6 884	50 300	35 190	137 000	148 000
Copper	1 483 429	2 540 118	7 250 000	13 206 324	16 100 000	19 200 000
Gold	585	753	1 200	2 555	2 660	3 110
Lead	1 585 033	1 666 317	3 600 000	3 051 684	4 400 000	5 000 000
Molybdenum	789	23 372	136 000	135 761	245 000	292 000
Nickel	37 594	147 733	752 000	1 226 506	1 605 000	2 092 000
Platinum group metals	7	19	178	444	481	459
Silver	778	5 505	9 242	18 201	23 387	27 511
Tin	149 359	169 883	228 000	249 026	329 000	341 000
Tungsten	9 168	18 492	48 000	30 644	63 400	80 900
Vanadium	4 165	2 813	26 000	32 531	69 000	72 000
Zinc	1 402 145	2 154 020	62 000 000	8 806 594	12 500 000	13 200 000
Uranium	288	not available	20 400	34 547	53 400	60 500

Table 2: Data for ‘all other minerals’, i.e. excluding coal, oil, natural gas, iron ore, aggregates and cement, degrees of rounding differ by commodity and year (see paper and supplemental information for details of how these figures have been used in the calculations). Source: British Geological Survey (1913–2017).