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Key Points:
- First high-resolution global sediments map
- Detailed global loess analysis

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Terrestrial Sediments of the Earth: Development of a Global Unconsolidated Sediments Map Database (GUM)

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Abstract Mapped unconsolidated sediments cover half of the global land surface. They are of considerable importance for many Earth surface processes like weathering, hydrological fluxes or biogeochemical cycles. Ignoring their characteristics or spatial extent may lead to misinterpretations in Earth System studies. Therefore, a new Global Unconsolidated Sediments Map database (GUM) was compiled, using regional maps specifically representing unconsolidated and quaternary sediments. The new GUM database provides insights into the regional distribution of unconsolidated sediments and their properties. The GUM comprises 911,551 polygons and describes not only sediment types and subtypes, but also parameters like grain size, mineralogy, age and thickness where available. Previous global lithological maps or databases lacked detail for reported unconsolidated sediment areas or missed large areas, and reported a global coverage of 25 to 30%, considering the ice-free land area. Here, alluvial sediments cover about 23% of the mapped total ice-free area, followed by aeolian sediments (∼21%), glacial sediments (∼20%), and colluvial sediments (∼16%). A specific focus during the creation of the database was on the distribution of loess deposits, since loess is highly reactive and relevant to understand geochemical cycles related to dust deposition and weathering processes. An additional layer compiling pyroclastic sediment is added, which merges consolidated and unconsolidated pyroclastic sediments. The compilation shows latitudinal abundances of sediment types related to climate of the past. The GUM database is available at the PANGAEA database (https://doi.org/10.1594/PANGAEA.884822).

1. Introduction

Numerous global maps focus on bedrock lithology or soil property distributions. Although unconsolidated sediments cover a substantial proportion of the land surface, a global scale high-resolution map or database, describing the multitude of unconsolidated sediments and their properties, is missing. They control weathering (Goddéris et al., 2013; Hartmann, 2009; Hartmann & Moosdorf, 2011; Moosdorf et al., 2011; Selvaraj & Chen, 2006) and hydrological fluxes (Gleeson et al., 2011, 2014), while at the same time they are the substrate for ecosystems, which influence biogeochemical cycles and feedback processes in the Earth system (e.g., Porder et al., 2007). Distribution patterns, thicknesses of sediments and grain size distribution provide insights into dynamical sedimentation processes, as well as erosion patterns and climatic conditions in the past (Muhs & Bettis, 2000, 2003).

In addition, a precise understanding of the layer between bedrock and soil is needed to assess the global water cycle and specifically water resources for anthropogenic needs (Brantley et al., 2007; de Graaf et al., 2017; Huscroft et al., 2018). For example, global permeability maps were derived from global lithological databases (Gleeson et al., 2011, 2014; Huscroft et al., 2018), to improve global water cycle models (de Graaf et al., 2017). These can be advanced by adding refined information on unconsolidated sediments above the bedrock. A more detailed picture is of particular interest since previous global lithological databases reported unconsolidated sediments for large areas, 24.6% of global land (Hartmann & Moosdorf, 2012) or 29.7% of the ice-free land surface (Dürr et al., 2005). However, some areas of the previously published map databases do not include unconsolidated sediments, but provide information on lithological units located below these sediments. To close this gap, an extensive search for regional maps specifically representing unconsolidated sediments was conducted. Based on the new database presented, a second version of the global hydrological maps (GLHYMPS2.0) was created, including grain size distribution (accompanying publication: Huscroft et al., 2018).

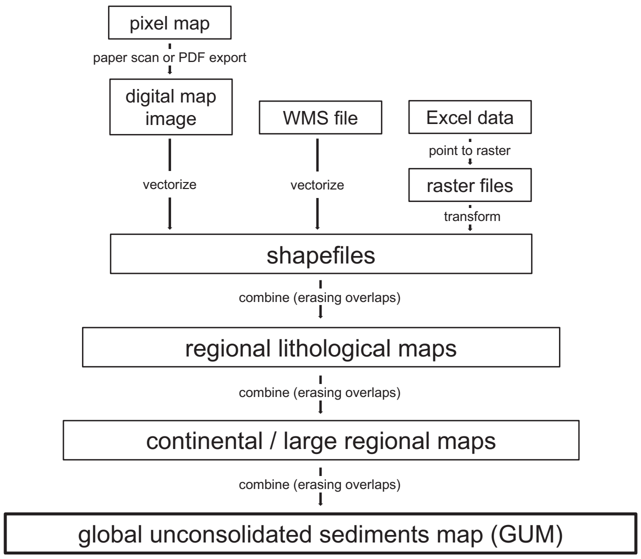

Figure 1. Simplified workflow of the GUM development.

The presented Global Unconsolidated sediment Map database (GUM) focuses on the distribution of loess, and various other sediment types like highly reactive pyroclastic material, glacial sediments (e.g., till or glacially derived peat deposits), alluvial sediments or dune sands. As almost any global map, this work relies on information from heterogenic regional sources. To ensure a unified map, data were restructured and categorized into a harmonized global scheme. Since availability and quality of data varies with region, additional global map sources were used to fill gaps.

2. Methods

The new global map database comprises all kinds of unconsolidated sediments, which are exposed on today's land surface. Furthermore, it contains information about evaporitic, biogenic deposits (e.g., reefs) and water and ice bodies, but no laterites or other residual deposits.

The GUM was derived by different types of input data sets. Preferred data sources were maps of quaternary sediments. If not available, general geological maps that provided both kinds of information, bedrock and sediments, were chosen. In addition, literature data on loess deposits and soil databases with information on the lithological characteristics of sediments were used. Figure 1 shows the simplified workflow of the GUM development.

Most of the data (126 map sources) were provided by national geological services in a machine readable format (71% of map sources). Further data were derived from analogue and digital imagery (29% of map sources) and vectorized using GIS (ESRI ArcMap 10.4). When no geological maps were available, information on unconsolidated sediments were taken from the Global Lithological Map database GLiM by Hartmann and Moosdorf (2012), given as class *su*. Most of the maps cover national areas, while some maps represent larger regions (e.g., the Balkans or Northern Africa). Where national maps were tiled, they were compiled (e.g., Mexico, Germany, Japan or Brazil).

Due to the heterogeneity of input data, a classification was developed (major classes shown in Table 1a and 1b; a full classification description is provided in Appendix A2). To reduce and homogenize the information given in map sources, five different levels of information are represented in the global unconsolidated sediment database. The first level identifies the sediment type (*XX*), which is defined in Appendix section A2.1. The second to fifth level subclasses indicate properties of the sediments (*YY* – grainsize information, *ZZ* – mineralogical information, *AA* – age information, *DD* – thickness).

All references of the incorporated individual data sets are listed in the Appendix A.

3. Results and Discussion

Mapped unconsolidated sediments cover around 50% of the global land area (referring to the total land area of the GLiM (Hartmann & Moosdorf, 2012), excluding ice and water bodies), or 68 x 10^6 km^2. In total, 911,551 polygons are distributed in the GUM, derived by 126 individual input data sets. The relative coverage and frequency of the sediment types (information level *XX*) can be seen in Tables 1a and 1b. The average map scale of the compiled map is 1:3,000,000 (area weighted).

Alluvial sediments cover ~23% of the mapped global ice-free area. Further larger groups of units are aeolian sediments (20.7%), glacial sediments (20.4%) and colluvial sediments (15.5%). Less areal extent can be observed for coastal sediments (~1.7%), lacustrine and organic deposits (1.2% and 1.1%), evaporitic deposits (0.9%), marine deposits (0.8%) and anthropogenic deposits (0.01%). Pyroclastic deposits are regarded separately since their definition is more complex. In the GUM, unconsolidated pyroclastics represent 0.1% of the total area, but the full extent of pyroclastic material (either consolidated or not further described) represents a larger area, with 0.7% of the total land area (related to the GLiM area; Hartmann & Moosdorf, 2012) respectively.

Table 1a
Areal Coverage of the Different Sediment Types, Globally as Well as for Distinguished Areas (Related to GUM Area)

XX	Description	Area (km^2)	Africa (%)	North America (%)	South America (%)	Europe (%)	Asia (%)	Australasia (%)	Relative global coverage (%)
A-	**Alluvial - all classes**	**15933162**	**31.80**	**10.11**	**39.17**	**17.56**	**22.35**	**15.98**	**19.21**
Au	Alluvial – Undifferentiated	12321831	30.23	9.62	19.69	13.94	17.84	2.32	14.85
Al	Alluvial – Lacustrine deposits	2196749	1.15		13.85	1.01	4.11		2.65
Ap	Alluvial – Plain deposits	766514		0.25	0.04	0.17		13.61	0.92
At	Alluvial – Terrace deposits	301025	0.41	0.15	1.82	1.59	0.18	0.05	0.36
Ae	Alluvial – Aeolian deposits	255395			3.76	0.18	0.02		0.31
Af	Alluvial – Fan deposits	91647	0.01	0.09		0.65	0.20		0.11
E-	**Aeolian - all classes**	**14411829**	**44.57**	**11.55**	**14.66**	**17.41**	**13.83**	**24.10**	**17.37**
Eu	Aeolian – Undifferentiated	5627447	36.67	0.20	3.42	1.39	1.35		6.78
Ed	Aeolian – Dunes	3871250	7.09	1.40	0.57	0.17	5.20	23.58	4.67
El	Aeolian – Loess deposits	2829142	0.61	3.11	6.71	14.01	4.95	0.50	3.41
Er	Aeolian – Loess derivates	1969164	0.20	6.82	3.96	1.77	1.91	0.02	2.37
Ea	Aeolian – Loess-like silt deposits	114827		0.02		0.07	0.41		0.14
G-	**Glacial - all classes**	**14197795**	**0**	**52.19**	**1.05**	**44.14**	**15.53**	**0.36**	**17.12**
Gt	Glacial – Till	9361460		40.48		25.88	7.17	0.06	11.28
Gl	Glacial – Glaciolacustrine deposits	1367292		4.83		1.54	1.98		1.65
Gu	Glacial – Undifferentiated	1301828			1.05	6.10	3.80	0.30	1.57
Gf	Glacial – Fluvioglacial deposits	1300673		1.79		10.60	2.48		1.57
Gm	Glacial – Glaciomarine deposits	561002		3.21		0.03	0.10		0.68
Gp	Glacial – Proglacial deposits	305540		1.88					0.37
Du	**Ice**	**13288447**	**0**	**12.30**	**0.31**	**0.06**	**0.33**	**0**	**16.02**
C-	**Colluvial - all classes**	**10819028**	**9.18**	**4.45**	**8.83**	**3.75**	**27.29**	**15.44**	**13.04**
Ca	Colluvial – Alluvial deposits	6718296		1.92	7.88	1.78	21.71		8.10
Cu	Colluvial – Undifferentiated	4100732	9.18	2.53	0.94	1.98	5.58	15.44	4.94
Us	**Sediments – Undifferentiated**	**8135182**	**5.20**	**0.49**	**28.09**	**6.00**	**12.21**	**38.98**	**9.81**
W-	**Water - all classes**	**2091321**	**2.36**	**4.85**	**2.15**	**2.65**	**2.75**	**0.30**	**2.52**
Wu	Water bodies – Undifferentiated	2068404	2.34	4.72	2.15	2.65	2.75	0.30	2.49
Wl	Water – Lakes	20113	0.02	0.11					0.02
Wr	Water – Rivers	2803		0.01					0.003
Y-	**Coastal - all classes**	**1152804**	**0.92**	**2.06**	**4.82**	**1.02**	**0.69**	**2.71**	**1.39**
Yu	Coastal – Undifferentiated	994965	0.92	1.84	4.43	0.94	0.57	1.51	1.20
Ys	Coastal – Swamp deposits	69674					0.02	1.21	0.08
Yd	Coastal – Delta sediments	42597		0.04	0.17	0.01	0.09		0.05
Yl	Coastal – Lagoonal sediments	41049		0.16	0.22	0.01			0.05
Yb	Coastal – Beach deposits	3565		0.01		0.06			0.004
Ym	Coastal – Marsh sediments	954				0.01			0.001
Lu	**Lacustrine deposits**	**867833**	**1.20**	**0.65**	**0.02**	**0.29**	**1.80**	**1.94**	**1.05**
O-	**Organic - all classes**	**800934**	**1.27**	**1.14**	**0**	**5.82**	**0.92**	**0.02**	**0.97**
Op	Organic – Peat deposits	762047	1.04	1.10		5.82	0.92	0.02	0.92
Ou	Organic – Undifferentiated	38758	0.23	0.04					0.05
Or	Organic – Reef deposits	130							0.0002
P-	**Evaporites - all classes**	**611160**	**2.44**	**0.21**	**0.72**	**0**	**0.74**	**0**	**0.74**
Ps	Evaporites – Salt deposits	332556	1.25		0.20		0.56		0.40
Pg	Evaporites – Gypsum deposits	133996	0.97	0.01					0.16
Pu	Evaporites – Undifferentiated	92634	0.21		0.52		0.11		0.11
Pp	Evaporites – Playa deposits	51975		0.20			0.07		0.06
Mu	**Marine deposits**	**534283**	**0.43**	**0.01**	**0.05**	**1.04**	**1.53**	**0.11**	**0.64**
Iy	**Pyroclastics**	**101282**	**0.64**	**0**	**0.12**	**0**	**0.01**	**0.08**	**0.12**
Zu	**Anthropogenic deposits**	**10088**	**0**	**0**	**0**	**0.26**	**0.01**	**0**	**0.01**

Note. Bold values represent main sediment types.

The remaining 11.7% of sediment cover are grouped as undifferentiated sediments (Us), which is in general a mixture of different sediment types or sediments of an undescribed origin. The comparably large fraction of undifferentiated sediments already points toward a potential to further improve the map database in future studies. The global distribution of the mapped sediment types can be seen in Figure 2.

Table 1b
Sediment Type Abundance in the Map Database

XX	Description	Abundance (number of polygons)	Africa (%)	North America (%)	South America (%)	Europe (%)	Asia (%)	Australasia (%)	Extent of global coverage (%)
A-	**Alluvial - all classes**	**212236**	**12.51**	**12.47**	**43.30**	**18.29**	**40.30**	**16.21**	**23.28**
Au	Alluvial – Undifferentiated	129200	11.36	11.88	35.84	15.91	15.33	3.24	14.17
Al	Alluvial – Lacustrine deposits	41406	0.29		4.43	1.59	14.68		4.54
At	Alluvial – Terrace deposits	24947	0.78	0.27	2.82	0.52	9.15	0.11	2.74
Ap	Alluvial – Plain deposits	12942		0.22	0.02	0.03		12.87	1.42
Af	Alluvial – Fan deposits	3656	0.08	0.10		0.24	1.12		0.40
Ae	Alluvial – Aeolian deposits	85			0.18		0.01		0.01
G-	**Glacial - all classes**	**160392**	**0**	**15.24**	**3.12**	**31.79**	**12.53**	**0.55**	**17.60**
Gt	Glacial – Till	82105		8.17		17.33	4.60	0.17	9.01
Gf	Glacial – Fluvioglacial deposits	48706		2.59		10.59	3.22		5.34
Gu	Glacial – Undifferentiated	18403			3.12	3.20	2.33	0.39	2.02
Gl	Glacial – Glaciolacustrine deposits	8207		1.18		0.58	2.29		0.90
Gp	Glacial – Proglacial deposits	1681		2.40					0.18
Gm	Glacial – Glaciomarine deposits	1290		0.89		0.10	0.10		0.14
O-	**Organic - all classes**	**116414**	**49.90**	**0.74**	**0.01**	**14.98**	**3.01**	**0.02**	**12.77**
Op	Organic – Peat deposits	115485	49.36	0.68		14.97	3.01	0.02	12.67
Ou	Organic – Undifferentiated	911	0.54	0.05		0.01			0.10
Or	Organic – Reef deposits	18		0.01	0.01				0
W-	**Water - all classes**	**104121**	**24.52**	**50.19**	**7.75**	**5.22**	**8.56**	**1.50**	**11.42**
Wu	Water bodies – Undifferentiated	95368	24.51	37.80	7.75	5.22	8.55	1.47	10.46
Wl	Water – Lakes	8746	0.02	12.38			0.01	0.03	0.96
Wr	Water – Rivers	7		0.01					0
Us	**Sediments – Undifferentiated**	**99583**	**2.88**	**0.24**	**12.21**	**8.33**	**11.40**	**35.28**	**10.92**
C-	**Colluvial - all classes**	**78173**	**4.79**	**3.16**	**12.99**	**3.13**	**13.60**	**24.27**	**8.58**
Cu	Colluvial – Undifferentiated	50934	4.79	2.13	3.28	2.82	3.76	24.22	5.59
Ca	Colluvial – Alluvial deposits	27239		1.03	9.71	0.31	9.84	0.06	2.99
E-	**Aeolian - all classes**	**67973**	**2.50**	**7.61**	**5.24**	**9.70**	**5.33**	**10.01**	**7.46**
El	Aeolian – Loess deposits	31339	0.02	4.52	2.41	5.20	1.48	4.92	3.44
Eu	Aeolian – Undifferentiated	14688	1.36	0.76	0.22	3.03	0.54		1.61
Ed	Aeolian – Dunes	13969	1.11	0.96	2.00	1.21	0.92	4.80	1.53
Er	Aeolian – Loess derivates	7258	0.01	1.22	0.62	0.24	2.18	0.30	0.80
Ea	Aeolian – Loess-like silt deposits	719		0.15		0.03	0.22		0.08
Y-	**Coastal - all classes**	**22077**	**1.52**	**4.50**	**13.74**	**1.78**	**0.95**	**3.39**	**2.42**
Yu	Coastal – Undifferentiated	16835	1.52	2.06	12.76	1.19	0.65	3.28	1.85
Yb	Coastal – Beach deposits	2025		0.09		0.46		0.01	0.22
Yl	Coastal – Lagoonal sediments	1602		1.94	0.85				0.18
Yd	Coastal – Delta sediments	752		0.40	0.14	0.10	0.02		0.08
Ys	Coastal – Swamp deposits	742					0.27	0.10	0.08
Ym	Coastal – Marsh sediments	121				0.03	0.01		0.01
Lu	**Lacustrine deposits**	**21702**	**0.20**	**0.95**	**0.07**	**2.39**	**1.53**	**8.48**	**2.38**
Zu	**Anthropogenic deposits**	**11717**	**0**	**0**	**0.09**	**3.11**	**0.02**	**0.03**	**1.29**
Mu	**Marine deposits**	**9096**	**0.15**	**0.05**	**0.40**	**1.10**	**1.79**	**0.22**	**1.00**
Du	**Ice**	**4477**	**0**	**4.53**	**0.02**	**0.17**	**0.24**	**0**	**0.49**
P-	**Evaporites - all classes**	**3056**	**0.84**	**0.32**	**0.68**	**0**	**0.66**	**0**	**0.34**
Ps	Evaporites – Salt deposits	1964	0.70		0.07		0.41		0.22
Pu	Evaporites – Undifferentiated	619			0.62		0.19		0.07
Pp	Evaporites – Playa deposits	321		0.30			0.05		0.04
Pg	Evaporites – Gypsum deposits	152	0.13	0.02					0.02
Iy	**Pyroclastics**	**534**	**0.18**	**0**	**0.39**	**0.01**	**0.08**	**0.03**	**0.06**

Note. Bold values represent main sediment types.

Significant regional differences can be observed. The area fraction of the GUM sediments relative to the land surface area shows e.g., that the northern hemisphere >50°N is almost entirely covered by mapped unconsolidated sediments, mostly because of glacial sediments (Figures 3 and 4). The high fraction of undifferentiated sediments may reflect the potential of a better classification of the sediments in future. Some

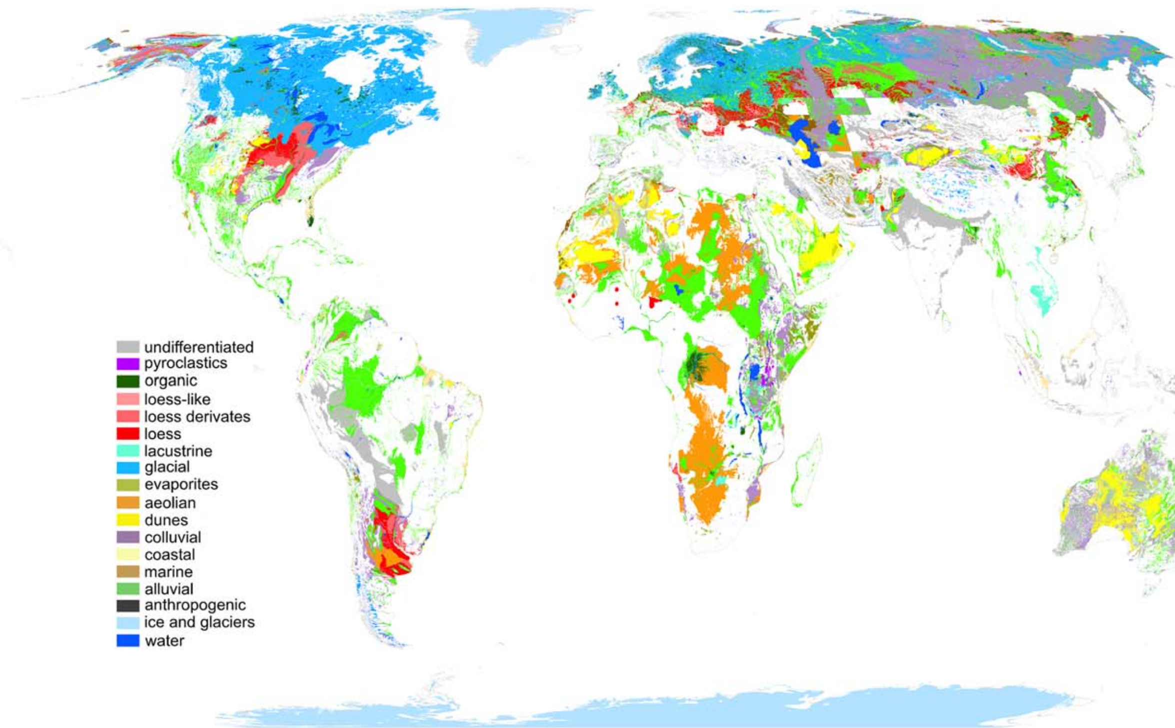

Figure 2. Map of the GUM database showing the different generalized sediment types (information level *XX*). Source: https://doi.org/10.1594/PANGAEA.884822.

can be attributed to arid areas, causing two peaks of undifferentiated aeolian deposits and dune deposits at latitudes of about 10° - 30°, N and S, respectively. Note that loess deposits are abundant in the latitudes between glacial sediments and dune deposits. The large fraction of mapped colluvial units for >50°N may be caused by solifluction, talus or deserptium deposits (stone streams and stone glaciers), which were classified as "colluvial" and are widely abundant in Russia.

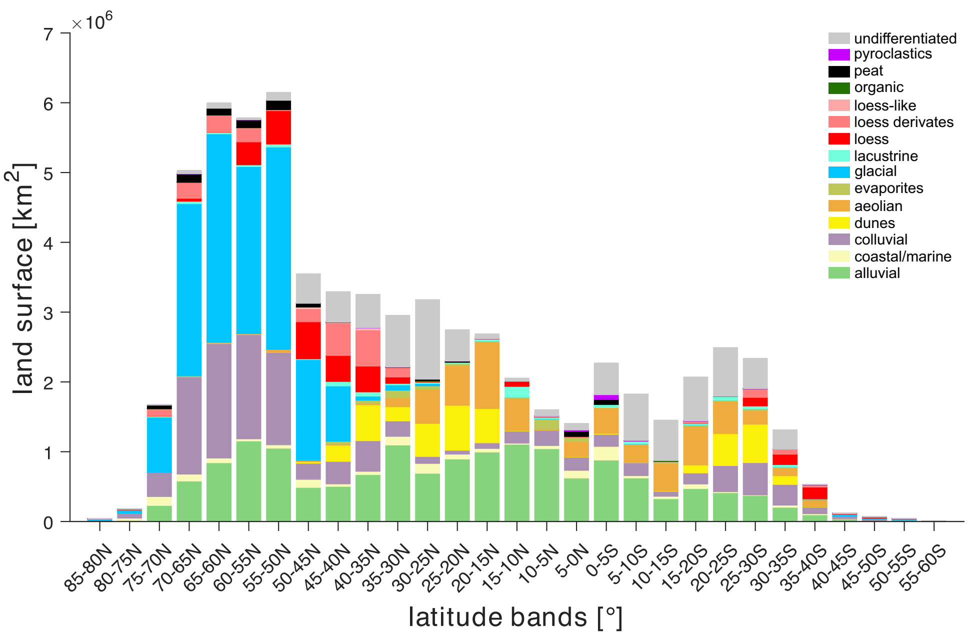

Figure 3. Latitudinal distribution of main sediment types. Source: https://doi.org/10.1594/PANGAEA.884822.

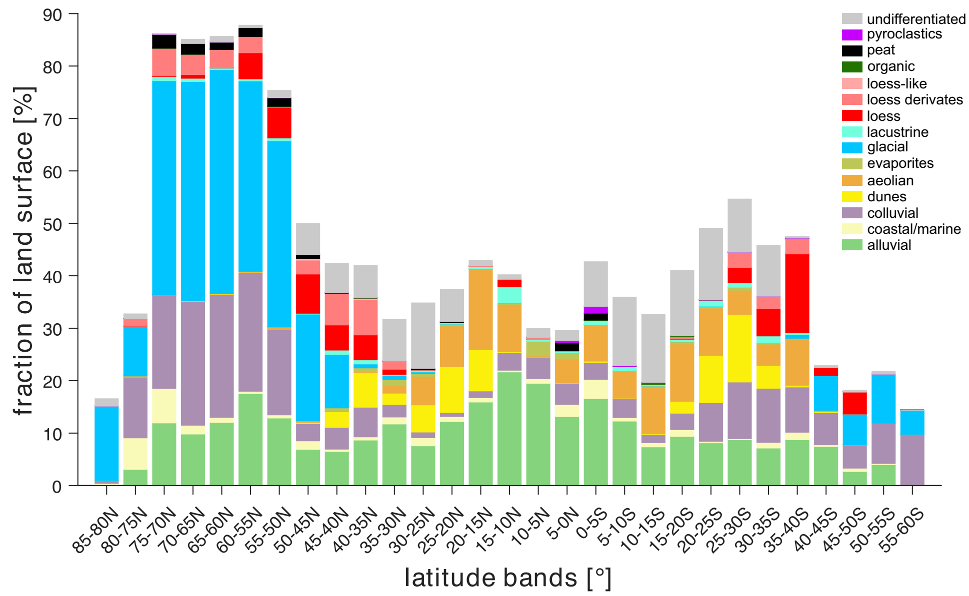

Figure 4. Fraction of land surface area covered by GUM sediments (land surface area, excluding water and ice bodies, derived from Hartmann and Moosdorf (2012)). Source: https://doi.org/10.1594/PANGAEA.884822.

In addition to sediment types, the GUM database provides data on sediment properties that are not often reported, but can give subordinate information on the sediments (Figure 5).

Grainsize information (information level *YY*) is available for about 39% of the polygons (covering 41.7% of the GUM area), excluding ice and water (0.4% clay and finer (cu), 2.7% silt and clay (lc), 3.8% silt (lu), 8.1% mixed (mx), 1.5% sand and clay (sc), 4.5% sand and silt (sl), 18.3% sand and coarser (su)).

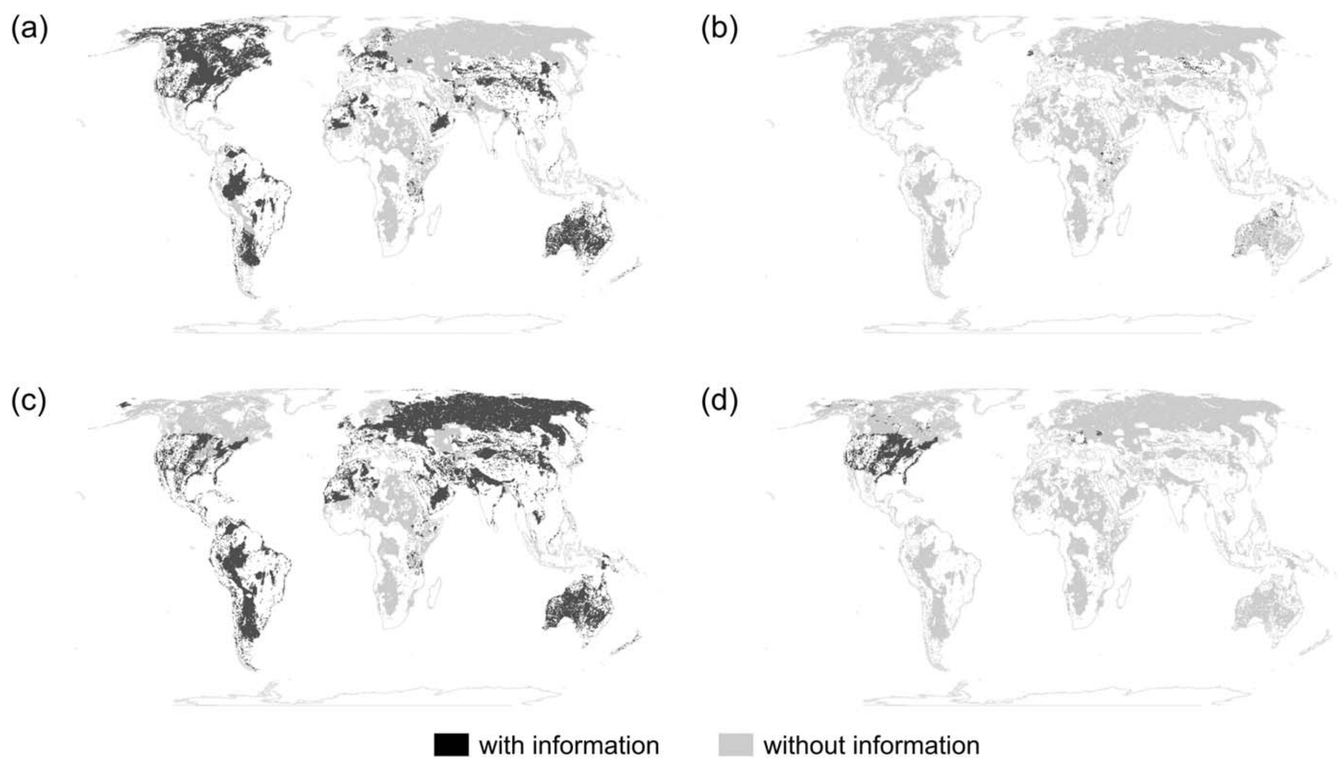

Figure 5. Maps showing the available information on (a) grainsize, (b) mineralogy, (c) age, and (d) thickness.

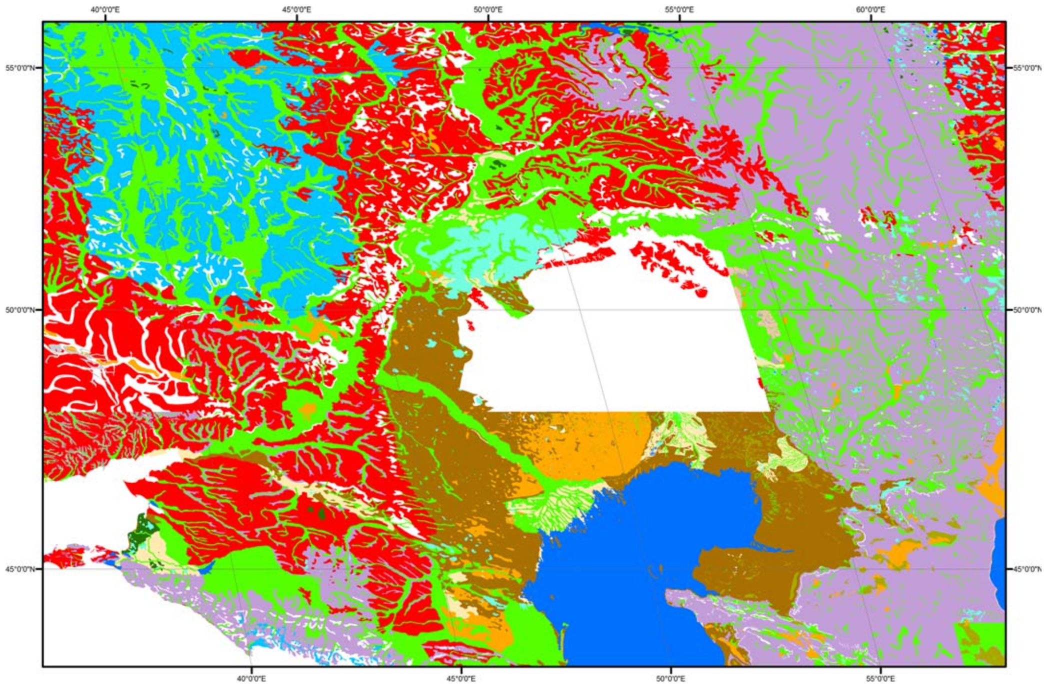

Figure 6. GUM sediment distribution in Central Asia. Since in the southern part of Russia remaining "white areas" are representing bedrock outcrops, some regions were not filled with data in this version of the GUM (e.g., NW Kazakhstan).

Only ~8% of the polygons contain information on the mineralogy (information level *ZZ*) (0.2% acidic (ac), 3.2% carbonatic (ca), 0.2% mafic (ma), 0.8% mixed (mx), 3.4% siliciclastic (ss); excluding ice and water).

Age information (information level *AA*) is available for ~73% of the polygons, excluding ice and water (11% Holocene (hu), 0.7% Early Pleistocene (pe), 7.6% Late Pleistocene (pl), 3.3% Middle Pleistocene (pm), 0.2% Plio-/Pleistocene (pp), 15.4% Pleistocene (pu), 5% Quaternary and/or Tertiary (qt), 28,3% Quaternary (qu), 1.8% Tertiary (tu), 0.03% others).

Information about sediment thicknesses (information level *DD*) is sparsely available for ~2% of the polygons (excluding ice and water).

Although the GUM database provides very detailed information about the distribution of unconsolidated sediments in some regions, e.g., Northern Europe or North America, there still remain some regions where identified data are comparably sparse, e.g., NE part of South America, SE Europe and central/SE Asia. Since unconsolidated sediments do not cover the entire globe, it remains unclear if "white areas" contain unmapped sediments or no sediments at all (Figure 6).

Different mapping techniques or data handling by different institutions naturally lead to heterogeneity of available classifications and rock/sediment characterization. Some institutions distinguish very strictly between bedrock and sediment, while others neglect sediments or classify them as soils. Future refinements should clarify the classification systems into rock, sediment and soil. Residual deposits (e.g., laterites or latosols) are not considered in this map database because we defined them as soils here. Another future target would be to obtain a multi-layered global map database of soils, sediments and bedrock to derive a most-comprehensive representation of the critical zone.

3.1. Global Loess Deposits

Loess deposits are reactive sediments with significant impact on the aquatic chemistry (Goddéris et al., 2013). Fertile soils can develop on top of loess sediments (Muhs et al., 2014) and due to their age, distinguishable, e.g., by luminescence analyses, loess deposits can be used to understand dynamic sedimentation processes in the past (Muhs & Bettis, 2003). They are important archives for studying long-term dust deposition and atmospheric circulation and, together with intercalated paleosols, they can represent detailed terrestrial records of glacial-interglacial cycles (Muhs et al., 2014). Thus, they are particularly interesting for

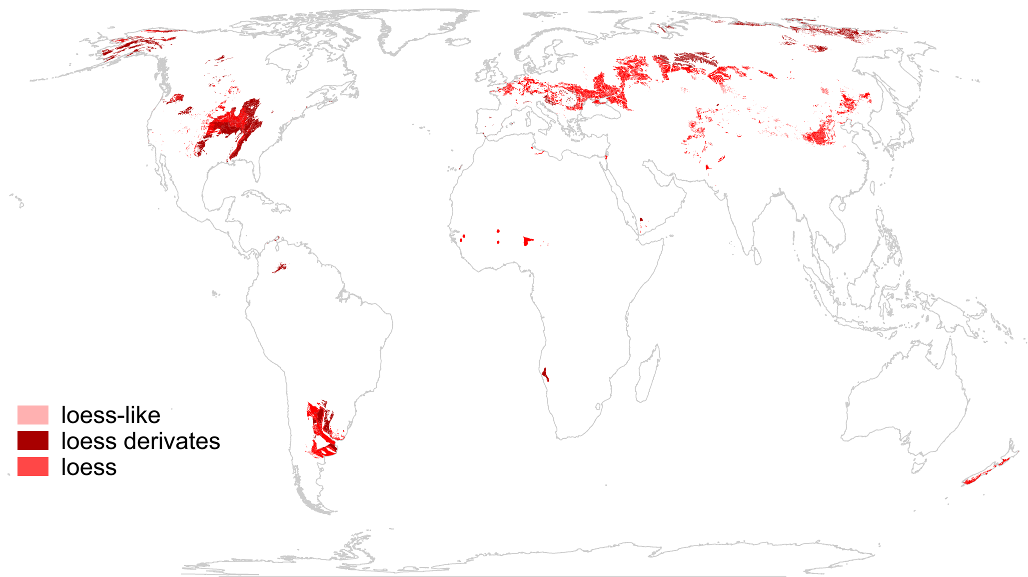

Figure 7. Global loess distribution derived from the GUM. Source: https://doi.org/10.1594/PANGAEA.884822.

climate studies. Loess sediments are distributed around the entire globe (Figure 7) but they vary significantly in thickness (from few cm to >400m, e.g., at Jingyuan in China (Derbyshire et al., 1998)).

Due to the intensive research on loess sediments, a global distribution pattern is of high demand. There exist various regional studies, but compiling a large-scale map database is challenging because of varying loess definitions, since there are several ways to generate, transport and accumulate silt particles (Muhs et al., 2014; Wright, 2001). Whether individual loess deposits are of glacial or non-glacial origin is not reported in the GUM. The loess sediments of the GUM are subdivided, following a classification after Pye (1984), into:

1. Loess deposits (El): aeolian silt deposits
2. Loess derivates (Er): reworked loess deposits
3. Loess-like sediments (Ea): silt deposits, but not of aeolian kind

Comparing a previous European loess map by Haase et al. (2007) with the GUM loess, the map of Haase et al. (2007) shows a quite homogeneous loess distribution with relatively large polygons. The new GUM

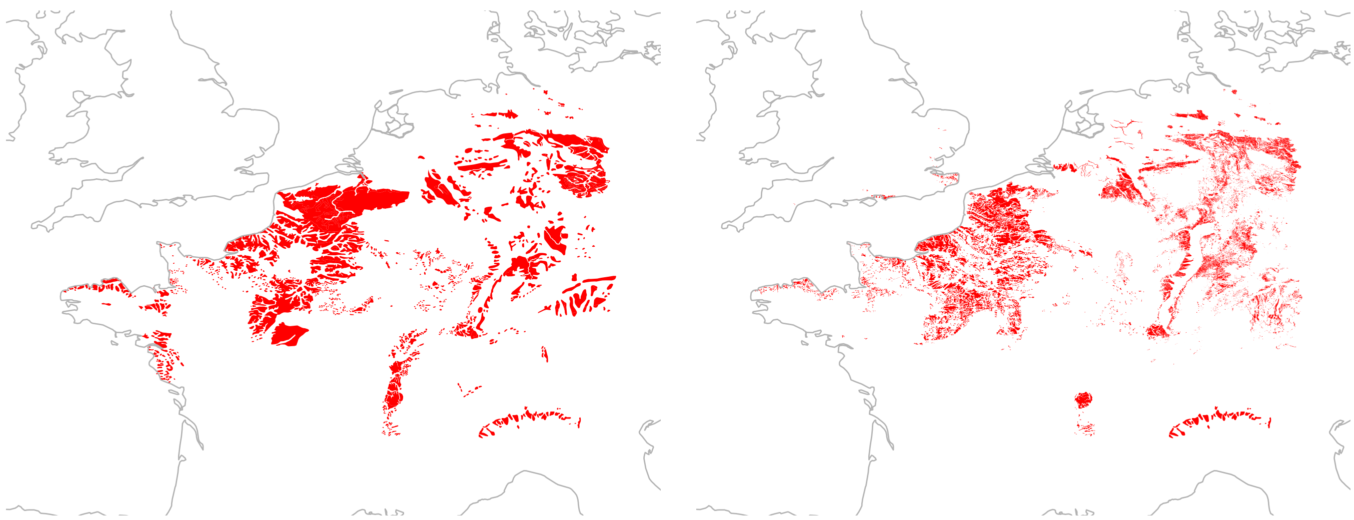

Figure 8. Loess distribution in Western Europe. Left: loess distribution of Haase et al. (2007), right: GUM loess (both loess and their related deposits), showing the different map resolutions. Whereas the loess coverage of Haase et al. (2007) is about 106,758 km^2, the GUM reveals a loess area extent of 64,056 km^2.

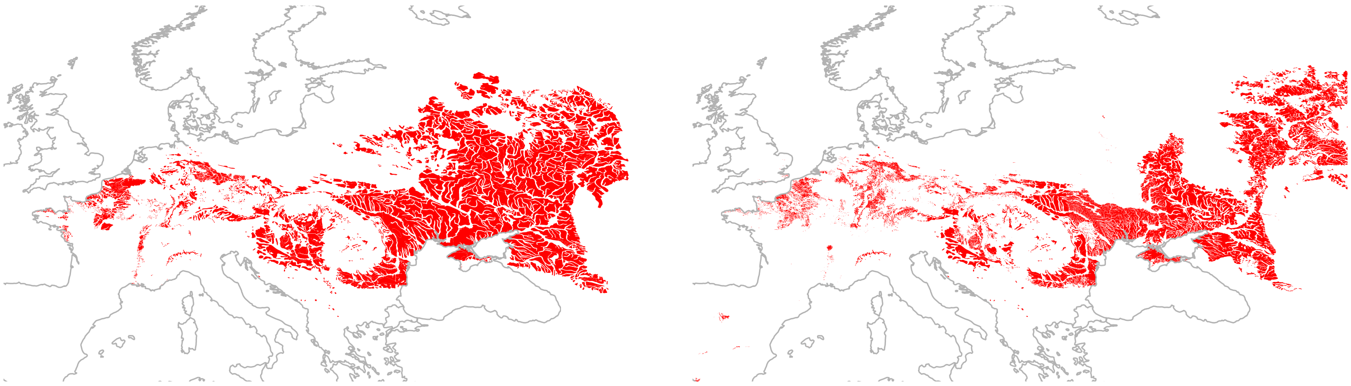

Figure 9. Loess distribution (El, Ea and Er) in Europe (left) after Haase et al. (2007) and (right) GUM loess distribution.

loess map, with a higher resolution of mapped loess from used sources, provides for Western Europe a significantly smaller mapped loess area (about 40%, cf. Figure 8).

The largest differences in spatial extent between the two maps in the European loess distribution can be seen in Belarus, the Ukraine and Russia (Figure 9). Fewer loess sediments are reported for those regions in the GUM because of differences in the loess definitions if compared to Haase et al. (2007). The original data used for the GUM show two types of information in these areas: Information on the sediment type and a lithological description of the sediment cover. For example, in Belarus exists a sediment cover that consists of boulders and sandy loam, but the underlying lithology is defined as of glacial origin (till), which leaves it unclear if the loam was derived by aeolian transport. Hence, this loam is not fitting into the classification system defined above and therefore not considered in the GUM as loess. These cover sediments may be patchy and their thickness might be very low. If loess deposits would have been classified less strictly, the global coverage of loess would increase.

4. Summary

The GUM database with its information on global terrestrial unconsolidated sediment distribution and their properties can be applied for a range of investigations on Earth system processes. With its resolution, improved compared to previous global maps (average map scale of 1:3,000,000), it provides information for studies on global surface processes. The special focus on loess, glacial sediments and pyroclastic material yields a large database describing their global distribution. The map database is created in a way that individual areas or regions of interest can be regarded separately and further information can be added to the database.

In addition to the database, a gridded version (0.5°) of the sediment types was created and is available, together with the GUM database, at the PANGAEA database (https://doi.org/10.1594/PANGAEA.884822).

Appendix A: Definitions, Sources, Methods

A1. Description of the Database

The information about sediment types, provided by the original map databases, had to be translated to a uniform new classification for the GUM. The quality of information varies enormously regarding the different sources for input data.

The database from the USA (see Table A2) for example provided very detailed sediment descriptions with up to 130 words, describing the sediment type, the grainsize, the age and the thickness.

Other databases, e.g., for Bolivia, provided rather sparse information, complicated to translate. For example, one unit was labeled “Depositos aluviales, fluvio-lacustres, fluvioglaciales, coluviales, lacustres, morrenas y dunas”, which was translated to “Alluvial, fluvial-lacustrine, glaciofluvial, colluvial, lacustrine, moraines and dune deposits” and since no unique sediment description was obtainable, classified as “Us”, sediments

Table A1
List of All the Sediment Classes of the GUM

Code	Description
XX – Sediment type	
Au	Alluvial, undifferentiated
Ae	Alluvial-aeolian
Af	Alluvial fans
Al	Alluvial-lacustrine
Ap	Alluvial plains
At	Alluvial terraces
Cu	Colluvial, undifferentiated
Ca	Colluvial-alluvial
Du	Ice and glaciers
Eu	Aeolian, undifferentiated
Ea	Loess-like silt
Ed	Dunes
El	Loess
Er	Loess derivates
Gu	Glacial, undifferentiated
Gf	Glacio-fluvial
Gl	Glacio-lacustrine
Gm	Glacio-marine
Gp	Proglacial
Gt	Till
Iy	Pyroclastics
Lu	Lacustrine
Mu	Marine
Ou	Organic, undifferentiated
Op	Peat
Or	Reef
Pu	Evaporites, undifferentiated
Pg	Gypsum
Pp	Playa
Ps	Salt
Us	Sediments, undifferentiated
Wu	Water bodies, undifferentiated
Wl	Lakes
Wr	Rivers
Yu	Coastal, undifferentiated
Yb	Beach
Yd	Deltaic
Yl	Lagoonal
Ym	Marshes
Ys	Swamps
Zu	Anthropogenic
YY – Grainsize information	
su	sand or coarser
sl	sand/silt
lu	silt
lc	silt/clay
cu	clay or finer
sc	sand/clay
mx	mixed
ZZ – Mineralogical information	
ac	acidic
ma	basic
ss	siliciclastic
ca	carbonatic
mx	mixed
AA – Age information	
hl	Late Holocene
hm	Middle Holocene

undifferentiated. Another unit in Bolivia was called "Gravas, arenas y arcillas" which gave only information on the grainsize distribution, but not about the sediment type (gravel, sand and clay). Hence, it was defined as "Us" as well, but with the grainsize information in information level YY.

These examples of very heterogeneous input data show the motivation for developing a new classification system that will be explained in the following.

A2. The Sediment Classification

The sediment classification was developed based on the availability of sediment descriptions in the input data sets, which is now represented by a ten-symbol code: "*XXYYZZAADD*," where "*XX*" represents the sediment type. The second to fifth level information provides further information considering sediment characteristics and is optional. The code "nn" in the database attribute table represents the lack of information. Table A1 lists all sediment classes and subclasses.

A2.1. First Level: Sediment Types (*XX*)

All units in the GUM feature information on the first level class *XX*, which describes the sediment type. The first large letter indicates the dominant group type in case of alluvial sediments (*A*), aeolian sediments (*E*), glacial sediments (*G*), coastal sediments (*Y*), organic sediments (*O*), evaporitic sediments (*P*), colluvial sediments (*C*) and water bodies (*W*). The second letter of those groups indicates a subgroup of the type, which is described below. Exceptions are marine deposits (*Mu*), Lacustrine deposits (*Lu*), pyroclastic material (*Iy*), undifferentiated sediments (*Us*), anthropogenic deposits (*Zu*) and Ice and glaciers (*Du*), where no further subtype differentiation was done.

A2.1.1. Alluvial Sediments (*A*-)

These are sediments that are deposited in an alluvial system. Sometimes the word "fluvial" was used to describe these sediments. They can be subdivided into alluvial fan sediments (*Af*), alluvial terrace sediments (*At*) or into alluvial floodplain sediments (*Ap*). If not only of alluvial origin, alluvial-aeolian sediments (*Ae*) or alluvial-lacustrine sediments (*Al*) can be described. The general term is "*Au*" for undifferentiated alluvial sediments.

A2.1.2. Colluvial Sediments (*C*-)

Colluvial sediments are here defined as mass-transported sediments by gravity. Original terms describing these sediments were for example "slope deposits", "talus", "deserptium" or "solifluction." In case of an alluvial influence they were classified as colluvial-alluvial sediments (*Ca*). "*Cu*" is defining colluvial sediments without further information.

A2.1.3. Aeolian Sediments (*E*-)

The Aeolian sediments group can be subdivided into Dune sands (*Ed*) and Loess deposits (*El*, *Er*, *Ea*).

Loess is typically defined as silt-dominated sediment that has been entrained, transported and deposited by the wind (Muhs et al., 2014). Primary aeolian loess should be separated from reworked loess and weathered loess. Loessoid deposits describe a mixture of aeolian dust and other material. Loess-like deposits are silt deposits but not of aeolian origin (e.g., alluvial loess, colluvial loess) (Pye, 1984). This results in a final loess classification as:

1. Loess deposits (windblown silt) - *El*
2. Loess derivates (reworked loess, loessoid deposits) - *Er*

Table A1. (continued)

Code	Description
hu	Holocene
ot	older than Tertiary
pe	Early Pleistocene
pl	Late Pleistocene
pm	Middle Pleistocene
pp	Pliocene-Pleistocene
pu	Pleistocene
qt	Quaternary-Tertiary
qu	Quaternary
tu	Tertiary
DD – Thickness information	
absolute values	in [m] or [ft]
dis	discontinuous or patchy

3. Loess-like deposits – *Ea*

The general term describing aeolian sediments without further information regarding their origin is "*Eu*."

A2.1.4. Glacial Sediments (*G*-)

Glacially derived sediments can be either of a glacio-fluvial origin (*Gf*), a glacio-lacustrine origin (*Gl*), a glacio-marine origin (*Gm*) or directly transported by the glacier in form of till sediments (*Gt*). Besides, there are proglacial deposits (*Gp*) and glacial deposits undifferentiated (*Gu*).

A2.1.5. Coastal sediments (*Y*-)

Coastal deposits consist of beach deposits (*Yb*), deltaic deposits (*Yd*), lagoonal deposits (*Yl*), marsh deposits (*Ym*) or swamps (*Ys*). In many regions where sediments were defined as alluvial/marine sediments they were reclassified into general coastal deposits (*Yu*).

A2.1.6. Marine Sediments (*Mu*)

These sediments are deposited in a marine environment. Most of these areas were not considered in the GUM because they are covered by water.

A2.1.7. Organic Deposits (*O*-)

Organic deposits can comprise peat and bog deposits (*Op*), modern reefs (*Or*) or undifferentiated organic deposits (*Ou*).

A2.1.8. Lacustrine Sediments (*Lu*)

These are sediments that are of lacustrine origin.

A2.1.9. Evaporitic Deposits (*P*-)

Evaporitic deposits can be subdivided into gypsum deposits (*Pg*), salt deposits (*Ps*) or playa deposits (*Pp*). The general term is "*Pu*."

A2.1.10. Pyroclastic Sediments (*Iy*)

For the pyroclastic material it was challenging to distinguish between consolidated and unconsolidated sediments. Therefore, pyroclastic material was only considered where it was clearly described as for example "ash", "lapilli" or "tephra." Note, there is an additional datalayer available reporting pyroclastic sediments including those areas, where it was not possible to determine if the sediment is consolidated or unconsolidated, without recherche going beyond the project time available.

A2.1.11. Undifferentiated Sediments (*Us*)

These sediments are either not further described or they consist of a mixture of different sediment types.

A2.1.12. Anthropogenic Deposits (*Zu*)

Anthropogenic deposits are described very rarely and can consist for example of dams, urban areas, mine waste deposits etc.

A2.1.13. Water Bodies (*W*-)

Water bodies, not sediments, comprise the following subunits: lakes (*Wl*) and rivers (*Wr*). Undifferentiated water bodies are classified as "*Wu.*"

A2.1.14. Ice and Glaciers (*Du*)

The term "*Du*" defines regions that are covered by ice.

A2.2. Grainsize Information (*YY*)

If grainsize information was available in the original database, this was reclassified as following:

1. sand or coarser (*su*)
2. sand and silt (*sl*) – often described as coarse-grained deposits
3. sand and clay (*sc*)
4. silt (*lu*)
5. silt and clay (*lc*) – often described as fine-grained deposits
6. clay or finer (*cu*)
7. mixed (*mx*) – if a mixture of grainsizes was reported

A2.3. Mineralogical Information (*ZZ*)

In some maps, there was information available regarding the mineralogical composition of a sediment. If it was reported that sediments were derived from igneous rocks that are acidic, meaning they contain higher

Table A2
Sources of the GUM

Region (country)	Source	Original format	Scale
Alaska	Ermann and O'Keife (1999)	Shapefile	1:1,584,000
Alaska	Muhs and Budahn (2006)	PDF	Not known
Canada	Fulton (1995)	Shapefile	1:5,000,000
Greenland	GLiM; Escher and Pulvertaft (1995)	Shapefile	1:2,500,000
USA	Soller et al. (2009)	Shapefile	1:5,000,000
USA – Regina	Fullerton et al. (2007)	Shapefile	1:1,000,000
USA – Chicago	Lineback et al. (2001)	Shapefile	1:1,000,000
USA – Des Moines	Hallberg et al. (2008)	Shapefile	1:1,000,000
USA – Dakotas	Fullerton et al. (2011)	Shapefile	1:1,000,000
USA – Hudson River	Fullerton et al. (2005)	Shapefile	1:1,000,000
USA – Lake Erie	Fullerton et al. (1991)	Shapefile	1:1,000,000
USA – Lookout Mountain	Miller et al. (2008)	Shapefile	1:1,000,000
USA – Louisville	Gray et al. (2011)	Shapefile	1:1,000,000
USA – Ozark Plateau	Whitfield et al. (2011)	Shapefile	1:1,000,000
USA – Platte River	Swinehart et al. (2006)	Shapefile	1:1,000,000
USA – Quebec	Borns et al. (2005)	Shapefile	1:1,000,000
USA – White Lake	Pope et al. (2012)	Shapefile	1:1,000,000
USA – Wichita	Denne et al. (2011)	Shapefile	1:1,000,000
USA – Winnipeg	Fullerton et al. (2000)	Shapefile	1:1,000,000
USA – Vicksburg	Holbrook et al. (2012)	Shapefile	1:1,000,000
USA – Peoria Loess	Kohfeld and Muhs (2001)	ASCII	1:1,000,000
USA – Snake River Plain and Palouse Loess	Bettis et al. (2003)	PDF	Not known
Mexico – Acapulco	Servicio Geológico Mexicano (2000a)	Shapefile	1:250,000
Mexico – Agua Prieta	Servicio Geológico Mexicano (2003a)	Shapefile	1:250,000
Mexico – Aguascalientes	Servicio Geológico Mexicano (1998a)	Shapefile	1:250,000
Mexico – Bahía Ascensión	Servicio Geológico Mexicano (2006a)	Shapefile	1:250,000
Mexico – Buenaventura	Servicio Geológico Mexicano (1998b)	Shapefile	1:250,000
Mexico – Caborca	Servicio Geológico Mexicano (2002a)	Shapefile	1:250,000
Mexico – Calkini	Servicio Geológico Mexicano (2005a)	Shapefile	1:250,000
Mexico – Campeche	Servicio Geológico Mexicano (2005b)	Shapefile	1:250,000
Mexico – Cananea	Servicio Geológico Mexicano (1999a)	Shapefile	1:250,000
Mexico – Cancún	Servicio Geológico Mexicano (2006b)	Shapefile	1:250,000
Mexico – Chetumal	Servicio Geológico Mexicano (2005c)	Shapefile	1:250,000
Mexico – Chihuahua	Servicio Geológico Mexicano (1997a)	Shapefile	1:250,000
Mexico – Chilpancingo	Servicio Geológico Mexicano (1998c)	Shapefile	1:250,000
Mexico – Ciudad Acuña	Servicio Geológico Mexicano (2003b)	Shapefile	1:250,000
Mexico – Ciudad Altamirano	Servicio Geológico Mexicano (2000b)	Shapefile	1:250,000
Mexico – Ciudad Camargo	Servicio Geológico Mexicano (2000c)	Shapefile	1:250,000
Mexico – Ciudad del Carmen	Servicio Geológico Mexicano (2005d)	Shapefile	1:250,000
Mexico – Ciudad Delicias	Servicio Geológico Mexicano (2000d)	Shapefile	1:250,000
Mexico – Ciudad de México	Servicio Geológico Mexicano (2002b)	Shapefile	1:250,000
Mexico – Ciudad Juárez	Servicio Geológico Mexicano (2003c)	Shapefile	1:250,000
Mexico – Ciudad Mante	Servicio Geológico Mexicano (1999b)	Shapefile	1:250,000
Mexico – Ciudad Obregón	Servicio Geológico Mexicano (2002c)	Shapefile	1:250,000
Mexico – Ciudad Valles	Servicio Geológico Mexicano (1997b)	Shapefile	1:250,000
Mexico – Ciudad Victoria	Servicio Geológico Mexicano (2004a)	Shapefile	1:250,000
Mexico – Colima	Servicio Geológico Mexicano (1999c)	Shapefile	1:250,000
Mexico – Concepción del Oro	Servicio Geológico Mexicano (2000e)	Shapefile	1:250,000
Mexico – Cozumel	Servicio Geológico Mexicano (2006c)	Shapefile	1:250,000
Mexico – Coatzacoalcos	Servicio Geológico Mexicano (2004b)	Shapefile	1:250,000
Mexico – Cuernavaca	Servicio Geológico Mexicano (1998d)	Shapefile	1:250,000
Mexico – Culiacan	Servicio Geológico Mexicano (1999d)	Shapefile	1:250,000
Mexico – Durango	Servicio Geológico Mexicano (1998e)	Shapefile	1:250,000
Mexico – El porvenir	Servicio Geológico Mexicano, http://mapasims.sgm.gob.mx/CartasDisponibles/, accessed March 2016	Shapefile	1:250,000
Mexico – El Salto	Servicio Geológico Mexicano (2000f)	Shapefile	1:250,000
Mexico – Ensenada	Servicio Geológico Mexicano (2003d)	Shapefile	1:250,000
Mexico – Escuinapa	Servicio Geológico Mexicano (1999e)	Shapefile	1:250,000
Mexico – Felipe Carrillo Puerto	Servicio Geológico Mexicano (2006d)	Shapefile	1:250,000

Table A2. (continued)

Region (country)	Source	Original format	Scale
Mexico – Fresnillo	Servicio Geológico Mexicano (1998f)	Shapefile	1:250,000
Mexico – Frontera	Servicio Geológico Mexicano (2004c)	Shapefile	1:250,000
Mexico – Guachochi	Servicio Geológico Mexicano (1999f)	Shapefile	1:250,000
Mexico – Guadalajara	Servicio Geológico Mexicano (2000g)	Shapefile	1:250,000
Mexico – Guanajuato	Servicio Geológico Mexicano (1997c)	Shapefile	1:250,000
Mexico – Guaymas	Servicio Geológico Mexicano (2002d)	Shapefile	1:250,000
Mexico – Guerrero Negro	Servicio Geológico Mexicano (1997d)	Shapefile	1:250,000
Mexico – Hermosillo	Servicio Geológico Mexicano (1999g)	Shapefile	1:250,000
Mexico – Hidalgo Del Parral	Servicio Geológico Mexicano (2000h)	Shapefile	1:250,000
Mexico – Huatabampo	Servicio Geológico Mexicano (2000i)	Shapefile	1:250,000
Mexico – Huixtla	Servicio Geológico Mexicano (2005e)	Shapefile	1:250,000
Mexico – Isla Ángel de la Guarda	Servicio Geológico Mexicano (2002e)	Shapefile	1:250,000
Mexico – Isla Cedros	Servicio Geológico Mexicano (2002f)	Shapefile	1:250,000
Mexico – Isla Cerralvo	Servicio Geológico Mexicano, http://mapasims.sgm.gob.mx/CartasDisponibles/, accessed March 2016	Shapefile	1:250,000
Mexico – Isla San Esteban	Servicio Geológico Mexicano (1998g)	Shapefile	1:250,000
Mexico – Islas Marías	Servicio Geológico Mexicano, http://mapasims.sgm.gob.mx/CartasDisponibles/, accessed March 2016	Shapefile	1:250,000
Mexico – Juan Aldama	Servicio Geológico Mexicano (1999h)	Shapefile	1:250,000
Mexico – Juchitán	Servicio Geológico Mexicano (2000j)	Shapefile	1:250,000
Mexico – La Paz	Servicio Geológico Mexicano (1999i)	Shapefile	1:250,000
Mexico – Las Margaritas	Servicio Geológico Mexicano (2006e)	Shapefile	1:250,000
Mexico – Lázaro Cárdenas	Servicio Geológico Mexicano (2002g)	Shapefile	1:250,000
Mexico – Lazarosouth	Servicio Geológico Mexicano, http://mapasims.sgm.gob.mx/CartasDisponibles/, accessed March 2016	Shapefile	1:250,000
Mexico – Linares	Servicio Geológico Mexicano (2004d)	Shapefile	1:250,000
Mexico – Loreto	Servicio Geológico Mexicano (2002h)	Shapefile	1:250,000
Mexico – Los Mochis	Servicio Geológico Mexicano (1997e)	Shapefile	1:250,000
Mexico – Los Vidrios	Servicio Geológico Mexicano (2002i)	Shapefile	1:250,000
Mexico – Madera	Servicio Geológico Mexicano (1999j)	Shapefile	1:250,000
Mexico – Manuel Benavides	Servicio Geológico Mexicano (2003e)	Shapefile	1:250,000
Mexico – Matamoros	Servicio Geológico Mexicano (2004e)	Shapefile	1:250,000
Mexico – Matehuala	Servicio Geológico Mexicano (1996)	Shapefile	1:250,000
Mexico – Manzanillo	Servicio Geológico Mexicano (2000k)	Shapefile	1:250,000
Mexico – Mazatlán	Servicio Geológico Mexicano (1999k)	Shapefile	1:250,000
Mexico – Mérida	Servicio Geológico Mexicano (2006f)	Shapefile	1:250,000
Mexico – Mexicali	Servicio Geológico Mexicano (2003f)	Shapefile	1:250,000
Mexico – Minatitlán	Servicio Geológico Mexicano (2000l)	Shapefile	1:250,000
Mexico – Monclova	Servicio Geológico Mexicano (1998h)	Shapefile	1:250,000
Mexico – Monterrey	Servicio Geológico Mexicano (2000m)	Shapefile	1:250,000
Mexico – Morelia	Servicio Geológico Mexicano (1998i)	Shapefile	1:250,000
Mexico – Nacozari	Servicio Geológico Mexicano (1998j)	Shapefile	1:250,000
Mexico – Nueva Casas Grandes	Servicio Geológico Mexicano (2002j)	Shapefile	1:250,000
Mexico – Nogales	Servicio Geológico Mexicano (2000n)	Shapefile	1:250,000
Mexico – Nueva Rosita	Servicio Geológico Mexicano (2000o)	Shapefile	1:250,000
Mexico – Nuevo Laredo	Servicio Geológico Mexicano (2004f)	Shapefile	1:250,000
Mexico – Oaxaca	Servicio Geológico Mexicano (2000p)	Shapefile	1:250,000
Mexico – Ocampo	Servicio Geológico Mexicano (2000q)	Shapefile	1:250,000
Mexico – Ojinaga	Servicio Geológico Mexicano (2003g)	Shapefile	1:250,000
Mexico – Orizaba	Servicio Geológico Mexicano (2001)	Shapefile	1:250,000
Mexico – Pachuca	Servicio Geológico Mexicano (1997f)	Shapefile	1:250,000
Mexico – Pericos	Servicio Geológico Mexicano (1999l)	Shapefile	1:250,000
Mexico – Piedras Negras	Servicio Geológico Mexicano (2003h)	Shapefile	1:250,000
Mexico – Poza Rica	Servicio Geológico Mexicano (2004g)	Shapefile	1:250,000
Mexico – Puerto Escondido	Servicio Geológico Mexicano (2002k)	Shapefile	1:250,000
Mexico – Puerto Peñasco	Servicio Geológico Mexicano (2002l)	Shapefile	1:250,000
Mexico – Puerto Vallarta	Servicio Geológico Mexicano (1999m)	Shapefile	1:250,000
Mexico – Punta San Antonio	Servicio Geológico Mexicano (2002m)	Shapefile	1:250,000
Mexico – Queretaro	Servicio Geológico Mexicano (1999n)	Shapefile	1:250,000
Mexico – Reynosa	Servicio Geológico Mexicano (2004h)	Shapefile	1:250,000

Table A2. (continued)

Region (country)	Source	Original format	Scale
Mexico – Río Bravo	Servicio Geológico Mexicano (2004i)	Shapefile	1:250,000
Mexico – San Antonio del Bravo	Servicio Geológico Mexicano (2003i)	Shapefile	1:250,000
Mexico – San Felipe	Servicio Geológico Mexicano (1999o)	Shapefile	1:250,000
Mexico – San Isidro	Servicio Geológico Mexicano (1998k)	Shapefile	1:250,000
Mexico – San José del Cabo	Servicio Geológico Mexicano (2002n)	Shapefile	1:250,000
Mexico – San Juanito	Servicio Geológico Mexicano (2000r)	Shapefile	1:250,000
Mexico – San LuisPotosí	Servicio Geológico Mexicano (1998l)	Shapefile	1:250,000
Mexico – San Miguel	Servicio Geológico Mexicano (2003j)	Shapefile	1:250,000
Mexico – Santa Rosalía	Servicio Geológico Mexicano (1997g)	Shapefile	1:250,000
Mexico – Santiago Papasquiaro	Servicio Geológico Mexicano (2000s)	Shapefile	1:250,000
Mexico – Sierralibre	Servicio Geológico Mexicano (2000t)	Shapefile	1:250,000
Mexico – Tamiahua	Servicio Geológico Mexicano (2004j)	Shapefile	1:250,000
Mexico – Tampico	Servicio Geológico Mexicano (2004k)	Shapefile	1:250,000
Mexico – Tapachula	Servicio Geológico Mexicano (2005f)	Shapefile	1:250,000
Mexico – Tecoripa	Servicio Geológico Mexicano (2000u)	Shapefile	1:250,000
Mexico – Tenosique	Servicio Geológico Mexicano (2006g)	Shapefile	1:250,000
Mexico – Tepic	Servicio Geológico Mexicano (1998m)	Shapefile	1:250,000
Mexico – Tijuana	Servicio Geológico Mexicano (2003k)	Shapefile	1:250,000
Mexico – Tizimín	Servicio Geológico Mexicano (2006h)	Shapefile	1:250,000
Mexico – Tlahualilo de Zaragoza	Servicio Geológico Mexicano (1998n)	Shapefile	1:250,000
Mexico – Torreón	Servicio Geológico Mexicano (2000v)	Shapefile	1:250,000
Mexico – Tuxtla Gutiérrez	Servicio Geológico Mexicano (2005g)	Shapefile	1:250,000
Mexico – Veracruz	Servicio Geológico Mexicano (2002o)	Shapefile	1:250,000
Mexico – Villa Constitución	Servicio Geológico Mexicano (2000w)	Shapefile	1:250,000
Mexico – Villahermosa	Servicio Geológico Mexicano (2005h)	Shapefile	1:250,000
Mexico – Zaachila	Servicio Geológico Mexicano (2000x)	Shapefile	1:250,000
Mexico – Zacatecas	Servicio Geológico Mexicano (1997h)	Shapefile	1:250,000
Mexico – Zihuatanejo	Servicio Geológico Mexicano (1999p)	Shapefile	1:250,000
Guatemala y el Caribe	French and Schenk (2004)	Shapefile	1:2,500,000
Colombia	Gomez Tapias et al. (2015)	Shapefile	1:1,000,000
Venezuela	Garrity et al. (2006)	Shapefile	1:750,000
Guyana, Suriname, Trinidad and Tobago	GLiM; Schobbenhaus and Bellizia (2001)	Shapefile	1:5,000,000
Ecuador	GLiM; Ortega et al. (1982)	Shapefile	1:1,000,000
Peru	GLiM; Instituto de Geologia y Mineria (1975)	Shapefile	1:1,000,000
Uruguay	GLiM; Dirección Nacional de Minería y Geología (1985)	Shapefile	1:500,000
Paraguay	GLiM; González (2000)	Shapefile	1:2,500,000
Chile	GLiM; Servicio Nacional de Geología y Minería (2004)	Shapefile	1:1,000,000
Brazil – Aracajú, Araguaia, Asunción, Belém, Belo Horizonte, Boa Vista, Brasilia, Campo Grande, Contamana, Corumbá, Cuiabá, Curitiba, Fortaleza, Goiânia, Goiás, Guaporé, Ica, Iguapé, Jaguaribe, Javari, Juruá, Juruena, Lago Amirim, Macapaindio, Manaus, Natal, Paranapanema, Pico Da Neblina, Porto Alegre, Porto Velho, Purus, Recife, Rio Branco, Rio de Janeiro, Rio Doce, Rio São Francisco, Salvador, Santarém, São Luis, Tapajós, Teresina, Tocantins, Tumucumaque, Uruguaiana, Vitória	Serviço Geológico do Brasil - CPRM (2014)	Shapefile	1:1,000,000
Bolivia	GeoBolivia (2000)	Shapefile	1:1,000,000
Argentina	GLiM; Servicio Geologico Minero Argentino (1997)	Shapefile	1:2,500,000
Burundi	Food and Agriculture Organization of the United Nations et al. (2003a)	Shapefile	1:350,000
Congo	van Engelen et al. (2006)	Shapefile	1:2,000,000
Kenya	Dijkshoorn (2007)	Shapefile	1:1,000,000
Malawi	Dijkshoorn et al. (2016)	Shapefile	1:1,000,000
Rwanda	Food and Agriculture Organization of the United Nations et al. (2003b)	Shapefile	1:350,000
Senegal, Gambia	Dijkshoorn and Huting (2014)	Shapefile	1:1,000,000

Table A2. (continued)

Region (country)	Source	Original format	Scale
Southern Africa	Dijkshoorn and van Engelen (2003)	Shapefile	1:2,000,000
Tanzania	Geological Survey of Tanzania, Geo-Economic Data (1:2M) – Geology http://www.gmis-tanzania.com/, accessed May 2016	Shapefile	1:2,000,000
Ethiopia	Tefera et al. (1996)	PDF	1:2,000,000
Tunisia	Dijkshoorn and Huting (2009)	Shapefile	1:1,000,000
Afrique du nord	Alimen and Choubert (1973)	Paper map	1:2,500,000
Sahara Occidental	Alimen and Choubert (1978b)	Paper map	1:2,500,000
Sahara Central	Alimen and Choubert (1978a)	Paper map	1:2,500,000
Africa	U.S. Geological Survey/The Nature Conservancy (2009)	Raster file	1:5,000,000
Peat in Congo	Dargie et al. (2017)	Raster file	50m
Loess in Africa	Crouvi et al. (2010)	PDF	Not known
Australia	Raymond et al. (2012)	Shapefile	1:1,000,000
New Zealand	GLiM; New Zealand Geological Survey (1972)	Shapefile	1:1,000,000
New Zealand – Loess	Landcare Research NZ Ltd (2010)	Shapefile	1:50,000
Antarctica	GLiM	Shapefile	1:10,000,000
Bangladesh	GLiM; Persits et al. (2001)	Shapefile	1:1,000,000
Cambodia	GLiM; Coordinating Committee for Geoscience Programmes in East and Southeast Asia (2004)	Shapefile	1:2,000,000
Philippines	GLiM; Coordinating Committee for Geoscience Programmes in East and Southeast Asia (2004)	Shapefile	1:2,000,000
Indonesia	GLiM; Geological Survey Institute of Indonesia (1993)	Shapefile	1:1,000,000
Papua New Guiney	GLiM; Coordinating Committee for Geoscience Programmes in East and Southeast Asia (2004)	Shapefile	1:2,000,000
Solomon Islands	GLiM; Steinshouer et al. (1999) and Turner (1978)	Shapefile	1:5,000,000 1:100,000
Fiji	GLiM; Colley (1976)	Shapefile	1:250,000
Australia	GLiM; Whitaker et al. (2007) GLiM; Raymond et al. (2007c) GLiM; Raymond et al. (2007b) GLiM; Raymond et al. (2007a) GLiM; Whitaker et al. (2008) GLiM; Stewart et al. (2008) GLiM; Liu et al. (2006)	Shapefile	1:1,000,000
Vanuatu	GLiM; Mollock (1974)	Shapefile	1:1,000,000
New Caledonia	GLiM; Direction de l'Industrie des Mines et de l'Energie (DIMENC) (1981)	Shapefile	1:200,000
Brunei	GLiM; Coordinating Committee for Geoscience Programmes in East and Southeast Asia (2004)	Shapefile	1:2,000,000
Laos	GLiM; Coordinating Committee for Geoscience Programmes in East and Southeast Asia (2004)	Shapefile	1:2,000,000
Malaysia	GLiM; Coordinating Committee for Geoscience Programmes in East and Southeast Asia (2004)	Shapefile	1:2,000,000
Myanmar	GLiM; Coordinating Committee for Geoscience Programmes in East and Southeast Asia (2004)	Shapefile	1:2,000,000
Thailand	GLiM; Coordinating Committee for Geoscience Programmes in East and Southeast Asia (2004)	Shapefile	1:2,000,000
Vietnam	GLiM; Coordinating Committee for Geoscience Programmes in East and Southeast Asia (2004)	Shapefile	1:2,000,000
Afghanistan	Doebrich et al. (2006)	Shapefile	1:500,000
Arabian Peninsula	GLiM; Pollastro et al. (1997)	Shapefile	1:4,500,000
Arabian Peninsula – Loess	Crouvi et al. (2010)	PDF	Not known
China	China Geological Survey (2002)	Shapefile	1:2,500,000
Himalaya	GLiM; Geological Survey of India (2005)	Shapefile	1:1,000,000
India	GLiM; Dasgupta and Chakravorty (1998)	Shapefile	1:2,000,000
Iran	Pollastro et al. (1999)	Shapefile	1:2,500,000
Japan	Geological Survey of Japan AIST (ed.) (2009), https://gbank.gsj.jp/seamless/download/downloadIndex_e.html, accessed May 2016	Shapefile	1:200,000
Mongolia	GLiM; Steinshouer et al. (1999)	Shapefile	1:5,000,000

Table A2. (continued)

Region (country)	Source	Original format	Scale
Nepal, Bhutan	GLiM; Wandrey and Law (1998)	Shapefile	1:10,000,000
Pakistan	Maldonado et al. (2011)	Shapefile	1:250,000
Pakistan	GLiM; Haghipour and Saidi (2010)	Shapefile	1:5,000,000
Sri Lanka	GLiM; Economic and Social Commission for Asia and the Pacific (1989)	Shapefile	1:1,000,000
Turkey	GLiM; Institute of Mineral Research and Exploration (1961)	Shapefile	1:500,000
Russia	Zastrozhnov et al. (2014)	PNG	1:2,500,000
Soviet Union (former)	GLiM; Karpinsky (1983)	Shapefile	1:2,500,000
Kazakhstan – M41/42, M40/41, N40/41, N43/44, L39/40, L38/39, L43/44, L44/45, M44/45, M38/39	карта четвертичных образованиЙ, http://webmapget.vsegei.ru/index.html, accessed June 2017	WMS	1:1,000,000
Kazakhstan/Usbekistan – L40/41, K41/42	карта четвертичных образованиЙ, http://webmapget.vsegei.ru/index.html, accessed June 2017	WMS	1:1,000,000
Kazakhstan/Usbekistan/Turkmenistan – K39/40	карта четвертичных образованиЙ, http://webmapget.vsegei.ru/index.html, accessed June 2017	WMS	1:1,000,000
Usbekistan/Turkmenistan – K40/41	карта четвертичных образованиЙ, http://webmapget.vsegei.ru/index.html, accessed June 2017	WMS	1:1,000,000
Kazakhstan/Kyrgyzstan – K43/44	карта четвертичных образованиЙ, http://webmapget.vsegei.ru/index.html, accessed June 2017	WMS	1:1,000,000
Kazakhstan/Kyrgyzstan/Usbekistan/Tajikistan – K42/43	карта четвертичных образованиЙ, http://webmapget.vsegei.ru/index.html, accessed June 2017	WMS	1:1,000,000
Usbekistan/Turkmenistan/Tajikistan – J41/42	карта четвертичных образованиЙ, http://webmapget.vsegei.ru/index.html, accessed June 2017	WMS	1:1,000,000
Tajikistan – J42/43	карта четвертичных образованиЙ, http://webmapget.vsegei.ru/index.html, accessed June 2017	WMS	1:1,000,000
Finland	Geologian tutkimuskeskus (2013)	Shapefile	1:1,000,000
Great Britain	British Geological Survey (2008)	Shapefile	1:625,000
Ireland	Meehan (2013)	Shapefile	1:25,000
Norway	Norges geologiske undersøkelse (2016)	Shapefile	1:250,000
Sweden	Geological Survey of Sweden (2014)	Shapefile	1:1,000,000
Austria	Geologische Bundesanstalt (GBA) (2013) and GLiM; Egger et al. (1999)	Shapefile	1:500,000 1:1,500,000
Belgium	GLiM; One Geology Europe Consortium (Surface geological maps of Europe, 2010, available at http://www.onegeology-europe.org/, accessed 17 January 2011) (hereinafter referred to as One Geology Europe Consortium 2010)	Shapefile	1:1,000,000
Czech Republic	GLiM; One Geology Europe Consortium 2010	Shapefile	1:1,000,000
Denmark	GLiM; One Geology Europe Consortium 2010	Shapefile	1:1,000,000
France	Lacquement et al. (2009)	PDF	1:1,000,000
Germany	Bundesanstalt für Geowissenschaften und Rohstoffe (2007)	Shapefile	1:200,000
Hungary	GLiM; One Geology Europe Consortium 2010	Shapefile	1:1,000,000
Italy	GLiM; One Geology Europe Consortium 2010	Shapefile	1:1,000,000
Luxembourg	GLiM; One Geology Europe Consortium 2010	Shapefile	1:1,000,000
Netherlands	GLiM; One Geology Europe Consortium 2010	Shapefile	1:1,000,000
Poland	GLiM; One Geology Europe Consortium 2010	Shapefile	1:1,000,000
Portugal	GLiM; One Geology Europe Consortium 2010	Shapefile	1:1,000,000
Slovak Republic	GLiM; One Geology Europe Consortium 2010	Shapefile	1:1,000,000
Slovenia	GLiM; One Geology Europe Consortium 2010	Shapefile	1:1,000,000
Spain	Instituto Geológico y Minero de España (1988)	Shapefile	1:1,000,000
Switzerland	GLiM; Bundesamt für Landestopografie (2005)	Shapefile	1:500,000
European Loess Map	Haase et al. (2007)	Raster	1:2,500,000
Albania	Ministria E Energjise dhe Industrise Sherbimi Gjeologjik Shqiptar (2014), https://geoportal.asig.gov.al, accessed February 2017	WMS-Server	1:100,000
Bosnia and Herzegovina	Tokic (1986)	Tiff	1:1,500,000
Bulgaria	Cheshitev et al. (1989)	JPG	1:500,000
Serbia	Kalenic et al. (2015)	PDF	1:300,000
Balkan	GliM; Pawlewicz et al. (1997)	Shapefile	1:5,000,000
Estonia	GLiM; One Geology Europe Consortium 2010	Shapefile	1:1,000,000
Lithuania/Belarus – N34/35	карта четвертичных образованиЙ, http://webmapget.vsegei.ru/index.html, accessed June 2017	WMS	1:1,000,000

Table A2. (continued)

Region (country)	Source	Original format	Scale
Moldova/Ukraine – L35/36	карта четвертичных образованиЙ, http://webmapget.vsegei.ru/index.html, accessed June 2017	WMS	1:1,000,000
Ukraine/Moldova/Belarus – M35/36	карта четвертичных образованиЙ, http://webmapget.vsegei.ru/index.html, accessed June 2017	WMS	1:1,000,000
Belarus/Ukraine – N35/36	карта четвертичных образованиЙ, http://webmapget.vsegei.ru/index.html, accessed June 2017	WMS	1:1,000,000
Ukraine – L36/37	карта четвертичных образованиЙ, http://webmapget.vsegei.ru/index.html, accessed June 2017	WMS	1:1,000,000
Latvia	Krasnov et al. (1971)	Tiff	1:2,500,000

levels of SiO_2, they were classified as "acidic" (*ac*). In case of a basic igneous origin with less SiO_2, containing relevant amounts of mafic minerals, the sediments were called "mafic" (*ma*).

Sediments that were derived from carbonate rocks or that have a primarily carbonatic composition, like reefs, are classified as "carbonatic sediments" (*ca*). Meanwhile, sediments containing a lot of silicate minerals, and which are derived by sandstones, siltstones or shales for example are called "siliciclastic" (*ss*).

Where a mixed mineralogy of the above named was mentioned the sediment was given the attribute "mixed" (*mx*).

A2.4. Age Information (*AA*)

Regarding the age classification of the sediments different types of classes could be identified. The most common are "Quaternary" (*qu*), meaning both Holocene and/or Pleistocene. Sediments of Holocene age in general (*hu*) can be further subdivided into "middle Holocene" (*hm*) or "late Holocene" (*hl*). Pleistocene age in general is indicated with "*pu*", whereas there exist also sediments of early Pleistocene age (*pe*), of the middle Pleistocene (*pm*) or the late Pleistocene (*pl*). Sediments of Pliocene-Pleistocene age are indicated with "*pp*." The Tertiary age is classified as "*tu*" and sediments of either Quaternary or Tertiary age or both have the index "*qt*."

But there are also older sediments identified, herein reclassified as "older than Tertiary" (*ot*). These sediments cover only small regions, only in maps of the former Soviet Union, Belgium and the Netherlands.

A2.5. Thickness Information (*DD*)

Thickness data of the individual sediments were obtained and implemented in the global database. The values are given either in meters or feet, visible in the attribute table. The term "*dis*" represents a reported discontinuous or patchy coverage.

A3. Sources of the GUM

All sources of the GUM are listed in Table A2. If possible, state-wide geological maps were used, but also maps of larger or smaller regions were implemented.

Table A3
Example of the Classification of Loess Classes of the NZ Soil Bureau

ROCK	TOPROCK	BASEROCK	*XX*
(Al+Lo)/St1	St1	St1	*Er*
Al/Lo	Al	Lo	*Er*
Al+(Lo)	Al	Al	*Er*
Al+Lo	Al	Al	*Er*
Al+Lo/Gr	Al	Al	*Er*
Lo/Al+Vo	Lo	Al	*El*
Lo+Tb	Lo	Lo	*Er*

A4. Geographical Combination Methods

In order to transform the diverse formats of the original maps into maps of a specified format they needed to be homogenized. Most of the maps could be directly downloaded in a digital format via websites of geological surveys. Often, those data were already in a shapefile format and could be directly read in into ArcMap.

Since the workflow of map processing is dependent of the original format (provided in Table A2), the different data transformations are described and can be seen in Figure 1.

1. Paper maps were scanned as pixel images at a resolution of 280 DPI (e.g., Northern Africa). Literature studies were also part of the data compilation method. Some pictures with loess distributions were taken from scientific papers and georeferenced for further processing in ArcMap.
2. Using ArcMap the pixel image maps were transformed into shapefiles by digitizing the individual polygons.
3. Some maps were only available on WMS servers. These maps needed to be digitized due to a lack of feature information.
4. For the data set of the Russian territory shapefiles were obtained with SAGA GIS (Conrad et al., 2015). Based on RGB codes of the individual units and running a majority filter (4x) it was possible to vectorize the grid classes to derive a shapefile. Erroneous white spaces due to structural geological features and map annotations that were also classified, were removed by the ArcMap tool "Euclidean Allocation."
5. For the Peoria loess (Kohfeld & Muhs, 2001), an Excel file with coordinates and point information was transformed into a raster file and then to a shapefile with ArcMap.
6. Collected shapefiles were imported into an ESRI file geodatabase and transformed to the Eckert IV projection.

In some cases the geometry of some maps had to be repaired because of "self-intersections" within the map. This was done by the "Repair geometry" tool in ArcMap (e.g., surficial lithology of Africa).

If maps still covered information on bedrock, these parts were deleted, as well as residual deposits. Some maps contained polygons that were covered by ocean (e.g., Canada, Sweden or Venezuela) or showed state territory of neighboring countries. These polygons were deleted manually from the maps if appropriate.

Due to the fact that not all maps provided data on water bodies or glaciated areas, all water bodies, ice, and glacier areas were taken from the GLiM (Hartmann & Moosdorf, 2012) and merged with the GUM.

The attribute tables of the original maps were then joined with the reclassified sediment descriptions (see section A2) and merged to state-wide and regional/continental shapefiles.

In cases of overlapping polygons, the parts of minor priority were deleted, favoring *i*) loess areas, *ii*) polygons with more detailed sediment description and *iii*) higher resolution data. The erase order within a country (several input data sets per country) and a detailed description of regional data source handling is given below.

A4.1. Alaska

For Alaska two input files were used; the State Surficial Geological Map and additional digitized data by Muhs and Budahn (2006). Where no loess data (*El* or *Er*) in the State Surficial Geological Map was available, the data by Muhs and Budahn (2006) was used.

A4.2. USA

If no loess data (*El*) in the surface geological map were available, the loess (*El*) was taken out from the regional maps and merged with the surface geological map. The same was done for the loess derivates (*Er*) and the loess-like silt deposits (*Ea*). Where data were overlapping, the first order priority was "*El*", second "*Er*" and third "*Ea*." The Palouse loess distribution (*El*) was only considered where no El-information of the surface geological map and the regional maps were available. Since the loess data from the Snake River and Palouse were digitized manually it was considered as (*Er*). These loess patterns were only included where no other loess data (*El*, *Ea*, *Er*) was available.

A4.3. North America (Alaska, Canada, USA) and Greenland

For the finalization of the North American map several other processing steps needed to be done. Since there was an *Er* occurrence in the Alaskan map within the Canadian territory, this polygon was erased from the Alaskan map and merged into the Canadian map. In some regions at the Canadian-American border the Canadian sediment information was more detailed. Only if the USA map had no loess occurrence the

Canadian sediments information was included into the American map. Finally Greenland was merged to the North American map.

A4.4. Mexico

The Mexican map had to be translated into English and was compiled from 120 individual shapefiles.

A4.5. Central America (Mexico and Guatemala y el Caribe)

The Mexican map was preferred over the Guatemala y el Caribe map.

A4.6. Colombia, Uruguay, Paraguay, Chile, Brasil, Bolivia, Argentina

These maps had to be translated to English.

A4.7. South America (Colombia, Venezuela, Guyana/Suriname/Trinidad and Tobago, Bolivia, Ecuador, Peru, Chile, Argentina, Uruguay, Brazil, Paraguay)

The maps were merged with following priority: Brazil, Uruguay/Chile/Colombia, Ecuador/Argentina, Bolivia/Paraguay, Peru/Guyana/Suriname/Trinidad and Tobago/Venezuela.

A4.8. Africa (Burundi, Congo, Kenya, Malawi, Rwanda, Senegal/Gambia, Southern Africa, Tanzania, Ethiopia, Tunisia, Northern Africa (1,2,3), Loess in Africa, African Surficial Lithology, Peat in Congo)

For the African continent, several maps had to be digitized (Ethiopia, Northern Africa 1,2,3; Loess in Africa). In case of overlapping areas after merging, the data of the more detailed map were kept. The digitized loess areas (Namibia, West Africa, Tunisia/Libya and Nigeria) were merged with the African map, as well as the peat data set for the Congo basin. The African Surficial Lithology map is kept as background data where no other data were available. The order of priority while merging Africa: Peat/Loess, Tunisia/Senegal_Gambia/Ethiopia, Kenya/Northern Africa 1, Rwanda/Northern Africa 2, Burundi/Northern Africa 3, Congo, Malawi, Tanzania, Southern Africa, African Surficial Lithology Map.

A4.9. New Zealand

In case of New Zealand two different input files were used; the geological map derived from the GLiM and data of the New Zealand soil bureau. Loess was only classified where "Lo" is on top. Remaining symbology was classified as loess derivates, a mixture of loess and other material (see Table A3).

Where no loess information in the GLiM map for New Zealand was given, the loess polygons of the New Zealand soil bureau were implemented.

A4.10. Aus/NZ/Antarctica (Australia, New Zealand, Antarctica)

These files were merged without bordering conflicts.

A4.11. Southeast Asia (Bangladesh, Cambodia, Australasia, Laos, Myanmar, Thailand, Vietnam)

In case of overlapping areas following merge order was used: Australasia/Bangladesh/Myanmar, Laos, Vietnam, Cambodia, Thailand, Malaysia.

A4.12. Arabian Peninsula

For the Arabian Peninsula two data sets were available; the map derived from the GLiM and additional literature data about loess deposits in Yemen, Israel and UAE. These loess patterns were merged into the GLiM map of the Arabian Peninsula.

A4.13. China

The Quaternary Geological Map of China was only available in Chinese language and no symbol explanation could be found. Therefore, the units were re-interpreted from the individual polygon descriptions. Where no clear sediment type could be identified, the unit was defined as "Us" (sediments, undifferentiated). In addition to the original Quaternary Geological Map of China, three other maps were available: Loess deposits (classified to *El*), loess-like deposits (classified to *Ea*) and deserts of China (classified to *Ed*). These four maps were combined following the priority: 1) Loess deposits, 2) Loess-like deposits, 3) deserts, 4) Quaternary Geological Map of China.

A4.14. Japan

The Japanese geological map was compiled from 175 different individual maps.

A4.15. Pakistan

For Pakistan two data sets were available, the map derived by the GliM covering the whole state and a more detailed map showing only a part of Pakistan. Where no information on loess was available, the smaller higher resolution map was merged into the GUM.

A4.16. Asia (Afghanistan, Arabian Peninsula, China, Himalaya, India, Iran, Japan, Mongolia, Nepal/Bhutan, Pakistan, Sri Lanka, Turkey)

In case of overlapping areas the map with the better classification or better geographic continuity was used, following the priority: China, Mongolia/Japan/Nepal/Bhutan/Afghanistan, Himalaya/Pakistan, India/Sri Lanka/Turkey, Iran, Arabian Peninsula.

A4.17. Russia

Since the Russian map was too large to be digitized manually in a reasonable timeframe, png-formatted images were downloaded and processed with SAGA GIS (Conrad et al., 2015). Based on the RGB colors and applying a majority filter (4x) a grid file was created, which was then transformed into a shapefile. Each color grid was given a classification after the original map. Remaining gaps due to technical issues were then filled in ArcMap with the Euclidean Allocation tool.

A4.18. WMS-files for Central Asia (Kazakhstan, Uzbekistan, Tajikistan, Kyrgyzstan, Turkmenistan)

For Central Asia 11 WMS-files were fully digitized, in 6 files only the loess areas were digitized, leaving room for refinements in the future.

A4.19. North Asia (Russia, Soviet Union, WMS-files)

The available files had the following priority during the merging process: Russia, M44/45/L43/44/M40/41, M41/42/N40/41/M38/39/L39/40, N43/44/K39/40, K40/41, L40/41, L38/39/J41/42, J42/43, K42/43, K41/42/K43/44, Soviet Union.

A4.20. Finland and Norway

The Finnish and Norwegian map had to be translated into English.

A4.21. Northern Europe (Finland, Great Britain, Ireland, Norway, Sweden)

In case of overlapping areas the map with the better classification or better geographic continuity was used, following the priority: Ireland/Finland, Great Britain/Sweden, Norway.

A4.22. Austria

The Austrian map consists of three different input data sets; the Geological Map of The Geological Survey of Austria (Geologische Bundesanstalt (GBA), 2013), the GLiM map (Hartmann & Moosdorf, 2012) and the Haase loess map covering Austria (Haase et al., 2007). These maps were merged in the same priority order named above.

A4.23. France

The French surficial geology map had to be translated into English and digitized manually.

A4.24. Germany

The German map was compiled from 55 individual maps, which had to be reclassified before merging.

A4.25. Italy, Slovakia, Slovenia

The loess distribution of the Haase map for Italy (Haase et al., 2007), Slovakia and Slovenia was included into the primary map sources derived from the GLiM.

A4.26. Spain

The Spanish Quaternary Geological Map had to be translated into English.

A4.27. Central Europe (Austria, Belgium, Czech Republic, Denmark, France, Germany, Hungary, Italy, Luxembourg, Netherlands, Poland, Portugal, Slovakia, Slovenia, Spain, Switzerland)

In case of overlapping areas the map with the better classification and/or loess information or better geographic continuity was used following the order: Netherlands, Germany, Denmark/Hungary, Poland/Czech Republic, Slovakia, Slovenia, Belgium, Luxembourg, Spain, Portugal/Switzerland, France/Italy, Austria.

A4.28. Albania

Ten different Albanian geological maps were only available from a WMS server. They were digitized manually and translated into English before merging. Additionally, loess patterns were included from Haase et al. (2007).

A4.29. Bosnia and Herzegovina

The geological map of quaternary basic types lithofacies of Bosnia and Herzegovina had to be digitzed manually and the loess distribution of Haase et al. (2007) was implemented.

A4.30. Bulgaria

The Bulgarian geological map had to be digitized manually.

A4.31. Serbia

The Serbian geological map had to be digitized manually. Two *Ea* sections were changed manually to *El* (Slobodan Markovic, pers. comm., 2016) and two polygons of the map of Haase et al. (2007) were inserted (Slobodan Markovic, pers. comm., 2016).

A4.32. Balkan (Albania, Bosnia and Herzegovina, Bulgaria, Serbia, Romania, Greece, Macedonia, Kosova, Montenegro, Croatia)

In case of overlapping areas the map with the better classification and/or loess information or better geographic continuity was used, following the order: Loess (Haase et al., 2007) for Croatia/Romania/Macedonia/Kosovo/Montenegro, Serbia, Bosnia and Herzegovina/Albania/Bulgaria, Romania/Greece/Macedonia/Montenegro/Kosovo/Croatia.

A4.33. Latvia

For Latvia a tiff-format pixel image was digitized.

A4.34. WMS-files for Lithuania, Belarus, Ukraine and Moldova

Five WMS-files were digitized.

A4.35. Eurasia (Belarus, Latvia, Lithuania, Estonia, Moldova, Ukraine)

Order of merging: Estonia/M3536, L3637, Moldova, N3536, Lithuania, Latvia, Soviet Union, Haase_loess.

A4.36. Merging the World

Following order: North America/South America, Mexico, Caribe, Northern Europe/Central Europe, Balkan, Eurasia, Australia/New Zealand/Antarctica, SE Asia, Asia, Northern Asia, Africa.

A4.37. Pyroclastic Layer

An additional layer of pyroclastics was created considering the unit *Iy* from GUM and a second pyroclastics unit: *Ic* (consolidated or not reported if consolidated or unconsolidated).

"*Ic*" was derived by the GUM input data (Mexico, Caribe y Guatemala, Colombia, Ecuador, Peru, Uruguay, Chile, Tanzania, Ethiopia, New Zealand, Australasia, Afghanistan, Japan, Russia, Czech Republic, Germany, Hungary, Portugal, Spain, Switzerland) and the GLiM (py) (Hartmann & Moosdorf, 2012).

Priority while merging: "*Iy*" from GUM, "*Ic*" from Mexico/Caribe/Colombia/Ecuador/Peru/Uruguay/Chile/Tanzania/Ethiopia/New Zealand/Australasia/Afghanistan/Japan/Russia/Hungary/Portugal/Spain/Switzerland/Germany, Czech Republic, "py" from GLiM.

A5. Contributors to GUM

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Erratum

In the originally published version of this article, there were several minor citation errors, none of which affected the conclusions of the paper. They have since been corrected, and this version may be considered the authoritative version of record.

In Table A2, the citation for Alimen (1973) was changed to Alimen and Choubert (1973).
In Table A2, the citations for Alimen (1978a) was changed to Alimen and Choubert (1978a).
In Table A2, the citations for Alimen (1978b) was changed to Alimen and Choubert (1978b).
In Table A2, Servicio Geológico Mexicano (2004i) was changed to Servicio Geológico Mexicano (2004h).
In Table A2, Servicio Geológico Mexicano (2003k) was changed to Servicio Geológico Mexicano (2003h).
In Table A2, Servicio Geológico Mexicano (2000p) was changed to Servicio Geológico Mexicano (2000h).
In the reference list, Ministria E Energjise dhe Industrise Sherbimi Gjeologjik Shqiptar (2014) was corrected.