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The new global lithological map database GLiM: A representation of rock properties at the Earth surface

Jens Hartmann and Nils Moosdorf
Institute for Biogeochemistry and Marine Chemistry, KlimaCampus, Universität Hamburg, Bundesstrasse 55, DE-20146 Hamburg, Germany (geo@hattes.de)

[1] Lithology describes the geochemical, mineralogical, and physical properties of rocks. It plays a key role in many processes at the Earth surface, especially the fluxes of matter to soils, ecosystems, rivers, and oceans. Understanding these processes at the global scale requires a high resolution description of lithology. A new high resolution global lithological map (GLiM) was assembled from existing regional geological maps translated into lithological information with the help of regional literature. The GLiM represents the rock types of the Earth surface with 1,235,400 polygons. The lithological classification consists of three levels. The first level contains 16 lithological classes comparable to previously applied definitions in global lithological maps. The additional two levels contain 12 and 14 subclasses, respectively, which describe more specific rock attributes. According to the GLiM, the Earth is covered by 64% sediments (a third of which are carbonates), 13% metamorphics, 7% plutonics, and 6% volcanics, and 10% are covered by water or ice. The high resolution of the GLiM allows observation of regional lithological distributions which often vary from the global average. The GLiM enables regional analysis of Earth surface processes at global scales. A gridded version of the GLiM is available at the PANGEA Database (http://dx.doi.org/10.1594/PANGAEA.788537).

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1. Introduction

[2] Lithological information, describing the geochemical and physical properties of rocks, is increasingly in demand in different disciplines of Earth system science. Lithology is a key variable in many fields, including landscape evolution [*de Caritat et al.*, 2012; *Coulthard*, 2001; *Dürr et al.*, 2011; *McAuliffe*, 1994], pathways of water fluxes [*Gleeson et al.*, 2011], river chemical composition [*Gibbs*, 1967; *Hartmann*, 2009; *Hartmann et al.*, 2010; *Meybeck*, 1987], isotope provenance [*Bataille and Bowen*, 2012; *Godfrey et al.*, 2009; *Lacan and Jeandel*, 2005], matter supply to ecosystems [*Porder et al.*, 2007] and lateral land ocean matter fluxes [*Berner*, 1994; *Godderis et al.*, 2009; *Hartmann*, 2009; *Hartmann and Moosdorf*, 2011; *Meybeck*, 1987; *Moosdorf et al.*, 2011].

[3] Lithology is often highly heterogeneous at the regional and local scale, and even small occurrences of certain rock types can provide important information for matter fluxes at the Earth's surface (e.g., carbonate or evaporite occurrence for river chemical compositions) [e.g., *Mast et al.*, 1990]. Lithological maps should therefore sufficiently represent this heterogeneity.

[4] There are three existing digital global lithological maps, developed by *Bluth and Kump* [1991] (revised by *Gibbs and Kump* [1994]), *Amiotte Suchet et al.* [2003], and *Dürr et al.* [2005]. The first two maps are grid-based representations, based on works of the Ronov group [e.g., *Khain et al.*, 1981], with a resolution of 2° and 1°, respectively, and distinguish 13 and 6 lithological classes. The latter map [*Dürr et al.*, 2005] is a vector-map translated from the second edition of a geological world map at a scale of 1:25,000,000 [*Dottin*, 1990], using additional literature. *Dürr et al.* [2005] distinguished 15 lithological classes (including water and ice) for application in weathering and hydrological studies ("hydrolithology").

[5] The development of regional to global scale lateral/land-ocean matter flux models [*Hartmann et al.*, 2010; *Jansen et al.*, 2010] has highlighted that the existing maps did not sufficiently represent the regional lithological variability in North America [*Moosdorf et al.*, 2010] or highly active weathering areas with small occurrences of relevant rock types [*Hartmann and Moosdorf*, 2011]. Thus, we developed a new global lithological map data set (GLiM) to represent rock properties at a sufficient resolution for the development and calibration of regional to global scale matter flux models. This publication describes the major characteristics of the new map. The map is designed in a way that can be easily enhanced, e.g., by age, tectonic or geochemical information, and can be applied to a wide range of studies.

2. Methods

[6] In this section, we briefly describe the methods applied to translate and assemble the global lithological map (GLiM). A detailed description of the preparation processes, including all individual map sources, is given in Appendix A.

[7] The GLiM was assembled from 92 regional lithological maps of the highest available resolution (target scale: 1:1,000,000). The selection of the geological source maps represents a compromise between detail (which would be best at a higher resolution), feasibility (high resolution data sets are difficult to handle at global scale) and consistency (all maps at one scale would be elegant). Most of the maps used were national or state geological maps, acquired from their individual developers, converted to a vector-based GIS usable format, and assembled into continental data sets using ESRI ArcGIS 10 software. The amount of processing depended on the original data format: paper maps were scanned and digitized by hand (i.e., each geological border was manually redrawn) whereas less conversion was necessary for maps already available in digital vector format. An accurate description of the lithological distribution requires a topologically sound data set, without holes or overlaps of individual polygons. We resolved more than 120,000 topological errors manually and automatically to correct for overlaps and gaps existing within the source maps and to harmonize borders of neighboring maps (see Appendix A for details).

[8] The descriptions of rocks – for simplicity, the term "rock" encompasses here all types of rocks including unconsolidated sediments – of the individual units were derived either from the geological maps (if available), or from additional literature. In total, 318 literature sources were used to describe the rocks, resulting in ~22,000 unique descriptors in the geodatabase. The geological boundaries between the source maps were not harmonized and rock descriptions were generalized into 16 lithological classes, based on the classification system by *Dürr et al.* [2005] (Table 1). To improve the representation of the regional heterogeneity, two additional levels of information were added as subclasses following *Moosdorf et al.* [2010] (Table 1). These subclasses add information to the first level lithological class (e.g., "siliciclastic sediment"), to describe additional lithological properties (e.g., the dominating grain size) or local special attributes (e.g., mapped coal occurrences or mentioned pyroclastics), which may be useful for analyses of a wide range of processes.

[9] The second level contains 12 and the third level 14 subclasses (Table 1). In the GLiM, a full lithological classification consists therefore of three two-digit codes ("xxyyzz"). The mandatory first level class (xx) represents the dominant lithology. The second (yy) and third (zz) optional level subclasses closer define the rocks and highlight local special attributes. However, yy and zz attributes

Table 1. The Lithological Classes, Subclasses and Literature Values of Previous Lithological Maps for Comparison[a]

Code	Description	Africa	Antarctica	Asia	Austasi	Europe	North America	South America	Global	Global – Literature Values: *Dürr et al.* [2005]	*Amiotte Suchet et al.* [2003]	*Gibbs and Kump* [1994]
						First Level						
ev	Evaporites	0.6%	0.0%	0.3%	0.5%	0.0%	0.1%	0.3%	0.3%	0.1%		
ig	Ice and Glaciers	0.0%	88.3%	0.1%	0.0%	0.0%	7.5%	0.1%	8.7%	0.2%		
mt	Metamorphics	27.6%	6.4%	6.9%	3.0%	13.6%	13.2%	12.6%	13.0%	4.1%	27.5%[b]	20.0%[b]
nd	No Data	0.0%	0.0%	0.2%	0.0%	0.0%	0.1%	0.0%	0.1%			
pa	Acid plutonic rocks	1.1%	0.7%	7.2%	3.6%	10.0%	8.5%	9.7%	5.7%	7.2%		
pb	Basic plutonic rocks	0.2%	0.5%	1.1%	1.0%	0.8%	0.8%	0.2%	0.7%	0.2%		
pi	Intermediate plutonic rocks	0.1%	0.0%	0.3%	0.3%	0.5%	0.9%	0.7%	0.4%			
py	Pyroclastics	0.0%	0.0%	0.6%	0.2%	0.1%	1.6%	1.4%	0.6%			
sc	Carbonate sedimentary rocks	9.4%	0.0%	10.0%	5.6%	17.6%	9.0%	1.5%	7.8%	10.4%	13.4%	9.3%
sm	Mixed sedimentary rocks	4.6%	1.0%	25.2%	14.2%	22.3%	15.3%	12.3%	14.6%	7.8%		
ss	Siliciclastic sedimentary rocks	16.4%	1.7%	14.9%	13.0%	14.7%	21.6%	25.7%	16.3%	16.3%	51.6%[c]	36.5%[c]
su	Unconsolidated sediments	35.1%	0.0%	24.0%	52.1%	15.3%	12.9%	26.4%	24.6%	29.7%		
va	Acid volcanic rocks	0.1%	0.0%	1.4%	1.1%	1.5%	1.6%	1.6%	1.0%	1.0%	2.3%	
vb	Basic volcanic rocks	3.3%	0.9%	4.2%	2.2%	2.8%	4.0%	4.2%	3.5%	5.8%	5.2%	6.8%
vi	Intermediate volcanic rocks	0.6%	0.5%	2.4%	3.1%	0.4%	1.7%	2.5%	1.7%			
wb	Water Bodies	0.9%	0.0%	1.3%	0.1%	0.4%	1.4%	0.8%	0.9%	0.6%		
pr	Precambrian rocks									11.5%		
Cl	Complex lithology									5.5%		27.5%
						Second Level: yy						
ad	Alluvial deposits	3.8%	0.0%	2.3%	12.4%	0.0%	3.1%	9.9%	4.1%	15.5%		
am	Mafic metamorphics mentioned	0.4%	0.0%	2.3%	0.7%	4.7%	0.7%	4.3%	1.7%			
ds	Dune sands	17.6%	0.0%	1.9%	12.4%	0.0%	0.0%	0.0%	5.3%	1.5%		
gr	Greenstone mentioned	0.0%	0.0%	0.1%	0.1%	0.3%	0.1%	0.3%	0.1%			
la	Laterites	0.0%	0.0%	0.4%	1.9%	0.1%	0.0%	3.0%	0.6%			
lo	Loess	0.0%	0.0%	3.1%	0.1%	0.0%	0.6%	0.2%	1.1%	2.6%		
mx	Mixed grain size	30.8%	2.4%	44.5%	28.7%	52.5%	29.5%	33.9%	33.5%			
or	Organic sediment	0.1%	0.0%	0.2%	0.6%	0.6%	0.1%	0.0%	0.2%			
pu	(Pure) carbonate	11.0%	0.0%	6.2%	6.4%	4.9%	4.5%	1.8%	5.9%			
py	Pyroclastics mentioned	1.5%	0.3%	6.4%	6.6%	3.6%	2.8%	5.3%	4.0%			
sh	Fine grained	1.7%	0.3%	9.1%	7.4%	5.8%	12.8%	5.2%	6.6%		25.4%[d]	12.6%[d]
ss	Coarse grained	1.0%	0.0%	4.1%	10.3%	4.7%	6.7%	10.2%	4.7%		26.2%[d]	23.9%[d]
						Third Level: zz						
bs	Black shale mentioned	0.0%	0.0%	0.5%	0.3%	0.6%	0.4%	0.5%	0.3%			
ch	Chert mentioned	0.1%	0.0%	0.2%	0.9%	1.1%	1.3%	0.2%	0.4%			
cl	Fossil plant organic material mentioned	0.2%	0.3%	5.1%	3.7%	2.1%	1.8%	4.1%	2.8%			
ev	Subordinate evaporites mentioned	0.0%	0.0%	8.5%	6.6%	2.8%	1.0%	3.8%	3.8%			
fe	Reduced-Iron minerals mentioned	0.1%	0.0%	0.1%	0.4%	0.1%	0.4%	0.5%	0.2%			

Table 1. (continued)

Code	Description	Africa	Antarctica	Asia	Austasi	Europe	North America	South America	Global	Global – Literature Values: *Dürr et al.* [2005]	*Amiotte Suchet et al.* [2003]	*Gibbs and Kump* [1994]
gl	Glacial influence mentioned	0.1%	0.0%	1.7%	0.6%	5.2%	0.9%	2.9%	1.3%			
mt	Metamorphic influence mentioned	0.9%	1.2%	3.8%	3.3%	8.8%	9.0%	4.6%	4.0%			
ph	Phosphorous-rich minerals mentioned	0.0%	0.0%	0.7%	0.0%	0.1%	0.0%	0.0%	0.2%			
pr	Subordinate plutonics mentioned	0.1%	0.0%	1.1%	0.5%	0.0%	0.4%	1.5%	0.6%			
pt	Pyrite mentioned	0.0%	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%			
sr	Subordinate sedimentary rocks mentioned	0.4%	1.2%	1.2%	1.2%	3.2%	0.9%	1.8%	1.1%			
su	Subordinate unconsolidated sediments mentioned	0.0%	0.0%	4.0%	1.0%	2.9%	0.1%	2.6%	1.7%			
vr	Subordinate volcanics mentioned	0.2%	0.8%	4.5%	1.7%	2.6%	2.5%	1.6%	2.3%			
we	Intensive weathering	0.0%	0.0%	1.9%	0.6%	0.0%	0.0%	0.0%	0.6%			

[a]The original classification was adapted to match the current classes where necessary and possible. Values represent the proportion of areal extent.
[b]Original class: "Shield rocks", including metamorphics and plutonics.
[c]Original classes: "Sand and Sandstones" and "Shale" [*Amiotte Suchet et al.*, 2003] as well as "Sandstones" and "Shales" [*Gibbs and Kump*, 1994]. Thus, the value for *Amiotte Suchet et al.* [2003] includes also unconsolidated sediments.
[d]Interpreted for comparison from the original classes "Sand and Sandstone", "Sandstone", and "Shale".

were not set if no special attributes were described in the used source of the lithological information.

3. Results and Discussion

[10] The new global map represents the global distribution of the different lithological classes in an unprecedented high resolution (Figure 1; see auxiliary material for a higher-resolution version of the map).[1] The map scale is on average 1:3,750,000 (area weighted). The assembled map consists in a total of 1,235,400 polygons.

[11] The terrestrial Earth surface is covered by 64% sediments (a third of which are carbonates), 13% metamorphics, 7% plutonics, and 6% volcanics (Table 1). No rock classes were assigned to areas of ice and inland water bodies, which cover 10% of the map area (including Antarctica). Significant regional differences in lithology distribution are observable: e.g., carbonate containing rock units represent 40% of the area in Europe while they represent only 14% in South America (Table 1).

[12] Not all mapped units are provided with second and third level information: 68% and 20% have an yy-subclass or a zz-subclass assigned, respectively. These subclasses allow additional analyses: e.g., 15% of the mapped sedimentary lithological classes (siliciclastic sedimentary rocks (SS), unconsolidated sediments (SU), mixed sedimentary rocks (SM), including carbonate sedimentary rocks (SC) are dominated by fine grained sediments and 8% are dominated by coarse grain sizes. About 9% of these classes represent pure carbonate sedimentary rock without mapped clastic sediments, and 62% are sediments of mixed or not determinable grain size. This example highlights the difficulties in representing the local heterogeneity of lithological properties, despite the high detail for the global data set. Another example for the use of the subclasses are evaporites in Asia, which are rarely dominant and are therefore mapped only in a few areas as lithological class (xx = ev: 0.28%). However, they occur subordinately in other lithological units covering a far larger area (zz = ev: 8.52%).

[13] In total, 437 different combinations of lithological classes (xx) and subclasses (yy, zz) occur. Development of a categorized lithological map is a continuous compromise between accuracy and simplicity. On the one hand, the diversity of the described variables demands as many classes as

[1]Auxiliary materials are available in the HTML. doi:10.1029/2012GC004370.

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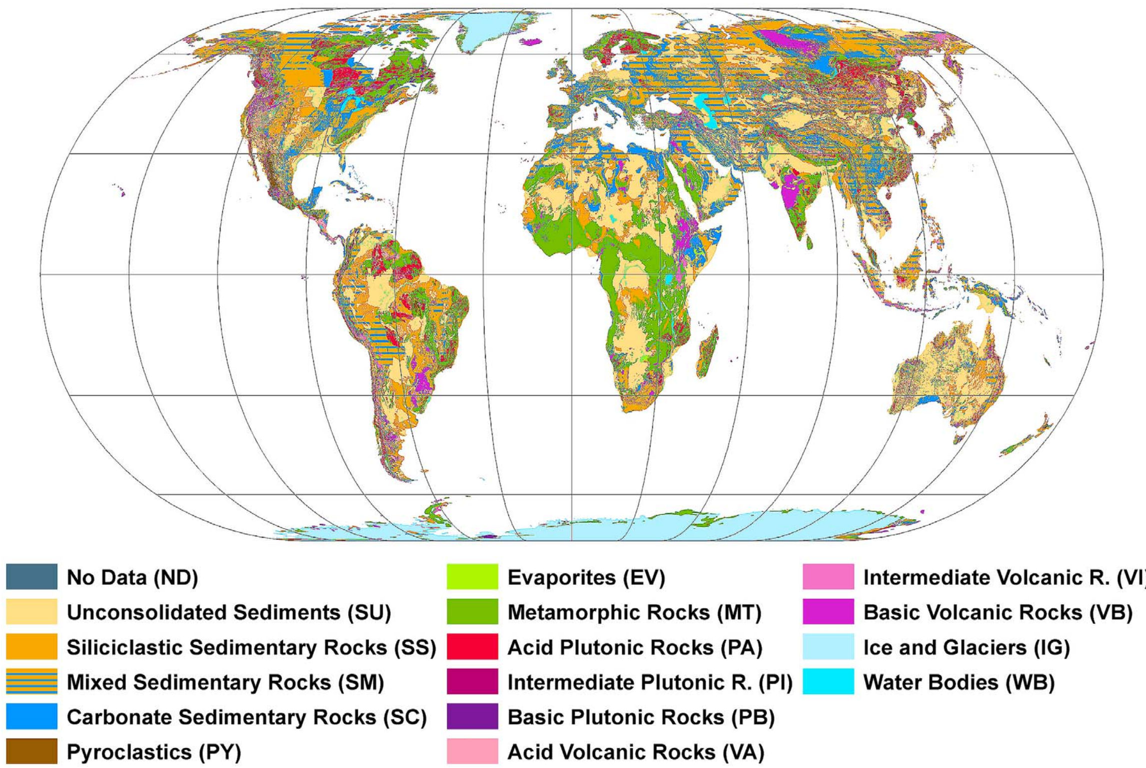

Figure 1. Representation of the global lithological map database (GLiM) showing the basic lithological classes (first level of information). Please note that the map resolution is finer than the print resolution (simplified gridded data available for download at http://dx.doi.org/10.1594/PANGAEA.788537).

possible to sufficiently represent individual features, but on the other hand, the number of classes should be minimized to improve usability. To optimize its usage, the GLiM features three class levels, which can be recombined as needed to represent the desired attributes for individual applications. However, the map is still subject to a significant uncertainty considering rock properties of some lithological classes, which is highlighted by the large amount of mixed sediments (xx = sm) at the Earth's surface (14.6%). Despite of that carbonate rocks and siliciclastic rocks are different, considering a large range of physical or chemical properties (e.g., dissolution rates or aquifer characteristics) they occur often "mixed" in one geological unit, undistinguishable at the scale of the here used maps.

[14] The third level subclasses (zz), including metamorphic influence mentioned (mt), subordinate plutonics mentioned (pr), subordinate sedimentary rocks mentioned (sr), subordinate volcanics mentioned (vr), and subordinate unconsolidated sediments mentioned (su), indicate the presence of rock types other than those defining the first level lithological class. The fact that these subclasses occur in 10% of the global area highlights the heterogeneity of the mapped lithological units and that they should not be considered as being homogenous. For example, the first level class "basic volcanics (vb)," although dominated by basalt can also contain layers of sediments. Moreover, such mixing effects do not only occur where they can be documented.

[15] This internal heterogeneity, considering needed local simplifications due to mapping at the given scales of source data, is also highlighted by a cross-check with 164,953 point data with information on lithology (see section A5 for details). These show a direct match to the mapped lithological classes of the GLiM in 40% of the cases. However, if further lithological classes of the GLiM, including information of subclasses, are considered to match the point data, 64% of the point information is represented by the GLiM.

[16] Although the general rock composition of the Earth's surface is remarkably similar between the existing digital lithological maps (Table 1), the

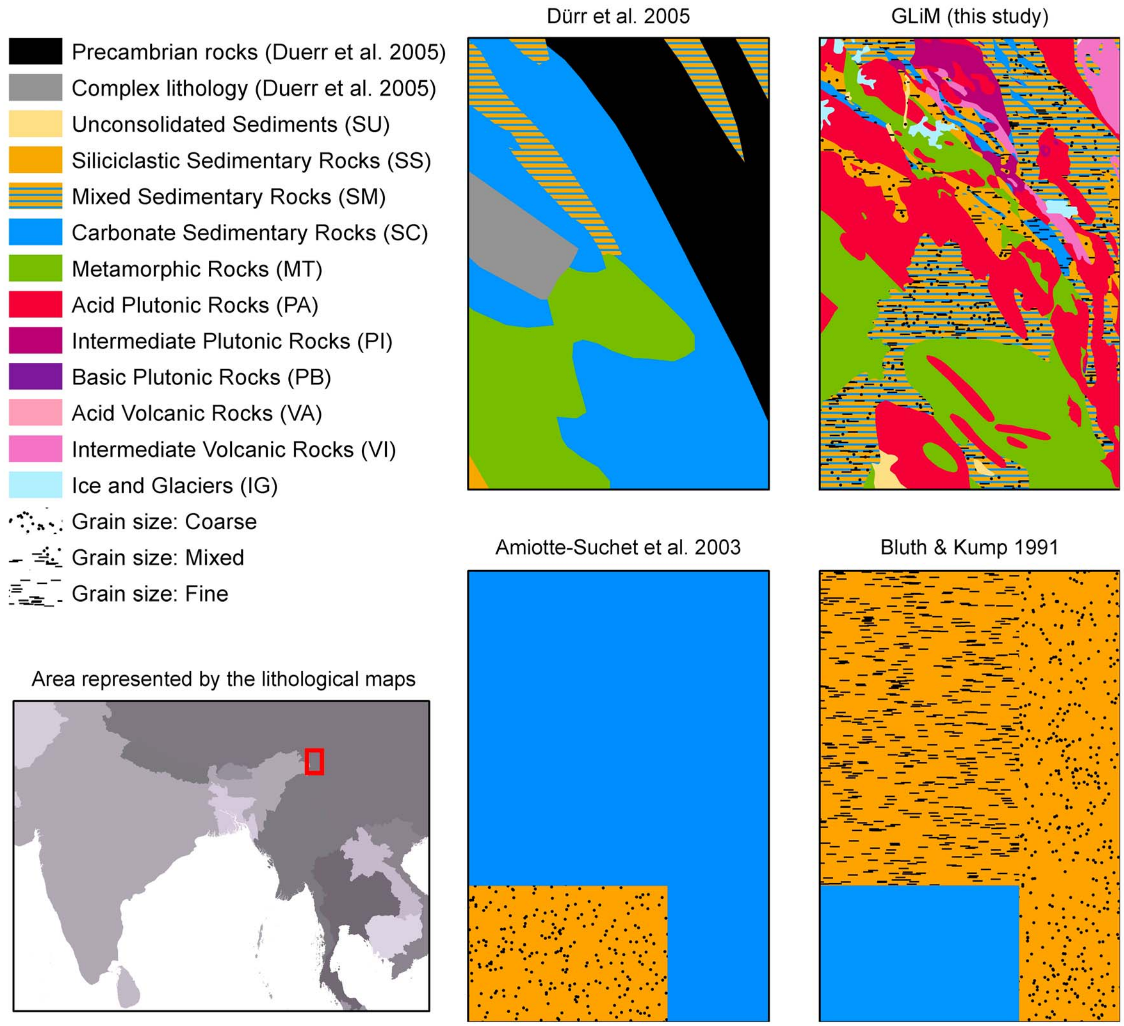

Figure 2. Comparison of the GLiM with previous lithological world maps for an example region in the eastern Himalayas. The scale of the detail lithological maps is 1:3,000,000.

representation of the rock distribution varies largely between them. Particularly the complex geological settings have been greatly improved in the GLiM compared to the previous maps (Figure 2), as it was previously shown for North America [*Moosdorf et al.*, 2010]. The improvement, visually observable in Figure 2, is also documented by a comparison with point information on lithology from geochemical databases (see section A5 for details). The 'ground-truth' evaluation of the GLiM results in 40% accurate data points (64% including 'similar' lithologies), whereas the lithological map of *Dürr et al.* [2005] accurately represents 30% of the data points, and the lithological maps of *Amiotte Suchet et al.* [2003] and *Bluth and Kump* [1991] correspond to 22% and 23% of the data, respectively. However, a direct comparison of the maps is difficult due to the broader classification system of the older maps, as for example the class "complicated lithology," which is resolved now to a more detailed classification in the GLiM. The design of the GLiM allows future inclusion of more detailed regional maps as well as additional information, e.g., age information of the lithological units or their tectonic history in future versions.

4. Summary

[17] The distribution of rock-attributes and rocktypes at a very high resolution ("average" scale 1:3,750,000) can represent the heterogeneity of the rocks at the Earth's surface. Strong differences in the lithological cover of the different continents are observable in the new global lithological map (GLiM) (Table 1).

[18] The GLiM allows the assessment of global scale research questions at high resolution and thus helps to advance our knowledge of Earth surface processes. The resolution facilitates comparison of results, e.g., of different regional matter flux studies. The regional differences between the properties of lithology could be used to better parameterize globally comparable regional models. In addition, the application of GLiM-derivates of distinct coarser resolution can be used to analyze scaling effects, which might be useful if such derivates are used in Earth system models. In addition, the architecture of GLiM allows more details or levels of information to be added and could thus be developed further in accordance with specific scientific questions. A gridded version of the GLiM for global scale studies is provided in the PANGEA database: http://dx.doi.org/10.1594/PANGAEA.788537.

Appendix A: Sources, Methods, Definitions

A1. Sources of the GLiM

[19] The Global Lithological Map (GLiM) was assembled from geological maps with a target resolution of 1:1 000 000 and ideally with a national extent or larger. However, if no suitable national geological map of the required quality was available, either coarser maps were used (e.g., in Africa), or finer maps assembled (e.g., the combined state geological maps of the preliminary geological map database of the conterminous U.S.A.). Table A1 lists all sources of the GLiM.

A2. Geographical Combination Methods

[20] To translate the geological maps into lithological maps and aggregate them, they needed to be in a standardized form. The preparation of each map differed according to the original format (original formats are provided in Table A1). The workflow is described in the following and in Figure A1:

[21] 1. Paper maps were scanned as pixel images using an A0-capable scanner at a resolution of 300 DPI.

[22] 2. Pixel images were transformed into shapefiles by manually clicking all the lines representing geological features and creating a shapefile in ArcEditor. Usually, the geological boundaries were cut from a mantling polygon to reduce topology errors. If possible, the image was converted to a black/white image before digitalization, to enable the use of the ArcScan tools (included in the ESRI ArcGIS package), which increase digitalization speed.

[23] 3. Vector PDF-files were converted into files of '.dxf'-format, and imported as line-features into ArcGIS, georeferenced, and converted to polygons using the ArcGIS tool "Line to Polygon." Those polygons were attributed by hand, and checked for errors due to the import procedure. In Somalia, the georeferencing of the original vector-pdf was not feasible with geographical transformations offered in ArcGIS. That map was rubber sheeted to the country borders after georeferencing, to reduce the spatial error.

[24] 4. MapInfo files were converted into shapefiles using the EVTools GIS and imported in ArcGIS.

[25] 5. Shapefiles were imported in an ESRI-file geodatabase and projected to the ECKERT IV projection (WGS84 ellipsoid as predefined in ArcGIS 10). The geological map of the Canaries needed to be manually spatially adjusted to its correct position, which was done based on the global shoreline data set [*Wessel and Smith*, 1996].

[26] The geometry of the shapefiles of some of the maps was corrupted, e.g., with "self intersections" (as well as some original data sets). Before they could be further processed, the geometry of the shape was repaired with the "repair geometry" tool (ArcGIS) and the results cross-checked with the original data. The areas that were particularly affected were Bolivia, Brazil, Chile, Indonesia, and Somalia.

[27] In some maps (e.g., in Bangladesh, Venezuela), large polygons represented the coastal ocean and larger rivers. The river part of these polygons was retained but the ocean part was erased. The border between retained river data and the erased ocean data was defined manually using satellite imagery (MS Bing® maps implemented in ArcGIS Online). Some of the original maps contained a large number of very small topological errors, which were first solved automatically by clustering polygon vertexes closer than a certain threshold apart. Affected areas and the thresholds were: Brazil (50 m), Somalia (500 m), Soviet Union (20 m).

[28] Some of the source maps contained holes for larger water bodies. The larger of these holes were filled with polygons and attributed as water body by hand; smaller holes were filled and merged automatically to the neighboring polygon sharing the longest border. Areas affected by that procedure are e.g., Brazil, Denmark, Indonesia, and Ireland.

Table A1. Sources of the GLiM as Well as Formats and Scale of the Map Source

Country (Region)	Map Sources	Lithology Sources	Original Format	Scale (1:X mil)
		Africa		
Africa	*Persits et al.* [2002]	*Alberti et al.* [1999], *Auchapt et al.* [1987], *Bow et al.* [2009], *Egyptian Geological Survey* [1981], *Furman and Graham* [1994], *Geological and Mineral Resources Department* [1981], *Geological Survey and Mines Department* [1973], *Hottin and Ouedraogo* [1976], *Kazmin* [1972], *Marzoli et al.* [2000], *Michel* [1973], *Nehlig et al.* [2006], *Németh et al.* [2003], *Persits et al.* [2002], *Saadi* [1982], *Schlüter* [2005], and *Wright* [1965]	Shapefile	7.5
Cape Verde	*Economic and Social Research Institute* (*ESRI*) [2008]	*ESRI* [2008]	Shapefile	10[a]
Madagascar	*Besairie* [1964]	*Besairie* [1964]	Mapinfo	1
Mozambique	*Pinna et al.* [1987]	*Pinna et al.* [1987]	Mapinfo	1
Namibia	*Geological Survey of Namibia* [1980]	*Geological Survey of Namibia* [1980]	Shapefile	1
Somalia	*Africover* [2002]	*Africover* [2002] and *Nyagah* [1995]	Vector PDF	1
South Africa	*Keyser* [1998]	*Keyser* [1998]	Shapefile	1
Spain (Canaries)	*Instituto Geológico y Minero de Espana* [1994]	*Instituto Geológico y Minero de Espana* [1994]	Shapefile	1
		Antarctica		
Antarctica	Scientific Committee on Antarctic Research (Antarctic digital database, 2012) and *Tingey* [1991a]	Scientific Committee on Antarctic Research (Antarctic digital database, 2012) and *Tingey* [1991a, 1991b]	Shapefile	10
		Asia		
Andaman Islands	*Steinshouer et al.* [1999]	*Allen et al.* [2008]	Shapefile	5
Arab Peninsula	*Pollastro et al.* [1997a]	*Abed and Amireh* [1999], *Al-Hafdh and Qasim* [1992], *Alsharhan and Nairn* [1994, 1995, 1997], *Alsharhan et al.* [1993], *As-Saruri et al.* [2010], *Hegner and Pallister* [1989], *Jassim and Goff* [2006], *Lustrino and Sharkov* [2006], *McClure* [1978], *Moshrif* [1984], *Natural Resources Project* [1990], *Pollastro et al.* [1997a], *Qari* [1989], *Sharief* [1982], and *Soliman and Elfetouh* [1970]	Shapefile	4.5
Bangladesh	*Persits et al.* [2001]	*Alam et al.* [2003] and *Persits et al.* [2001]	Shapefile	1
Cambodia	*Coordinating Committee for Geoscience Programmes in East and Southeast Asia* (*CCOP*) [2004]	*CCOP* [2004] and *Fromaget and Saurin* [1952]	Shapefile	2
China	*China Geological Survey* [2001]	*China Geological Survey* [2001]	Shapefile	2.5
China Nei Mongol	*Ministry of Geology and Mineral Resources of the People's Republic of China* [1991]	*Ministry of Geology and Mineral Resources of the People's Republic of China* [1991]	Shapefile	1.5

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Table A1. (continued)

Country (Region)	Map Sources	Lithology Sources	Original Format	Scale (1:X mil)
China Xinjiang	*Bureau of Geology and Mineral Resources of Xinjiang* [1992]	*Bureau of Geology and Mineral Resources of Xinjiang* [1992]	Shapefile	1.5
Himalaya	*Geological Survey of India* [2005]	*Ahmad and Bhat* [1987], *Ahmad and Tarney* [1991], *Balasubrahmanyan* [2006], *Bhat et al.* [1994a], *Bhat et al.* [1994b], *Dunlap and Wysoczanski* [2002], *Fuchs* [1975], *Ganeshan et al.* [1982], *Geological Survey of India* [1979, 2005], *Hambrey et al.* [1981], *Joshi et al.* [1990], *Kumar and Singh* [1983], *Macfarlane et al.* [1999], *Radhakrishna et al.* [1984], *Sabir Khan* [1994], *Singh and Jain* [2003], *Sinha* [1989], *Sinha and Nautiyal* [1981], *Sinha et al.* [1999], *Srimal* [2005], *M. J. Streule et al.* [2009], and *Valdiya and Bhatia* [1980]	Paper map	1
India	*Dasgupta and Chakravorty* [1998]	*Bhatia and Bhatia* [1973], *Bhushan* [1998], *Bhushan et al.* [1991], *Central Ground Water Board* [2009], *Clark* [2005], *Dasgupta and Chakravorty* [1998], *Deb et al.* [1978], *Deb et al.* [2002], *Dunlap and Wysoczanski* [2002], *Fuchs and Sinha* [1978], *Geological Survey of India* [2009], *Ghose et al.* [2010], *Krishnan* [1968], *Kumar et al.* [1984], *Kumar and Pankaj* [2009], *Kumar* [1985], *Lakhera et al.* [1980], *Mazumdar and Bhattacharya* [2004], *Mishra* [2009], *Mukherjee et al.* [1992], *Myrow et al.* [2006], *Nag et al.* [1999], *Nayak et al.* [2009], *Pande and Kumar* [1965], *Patwardhan* [2010], *Rana et al.* [2005], *Sharma and Bhola* [2005], *Sharma* [2007], *Sharma and Thomas* [2005], *Shekhawat and Prabhulingaiah* [2010], *Singh* [2010], *Singh* [2011], *M. J. Streule et al.* [2009], *Sundaram et al.* [2001], *Sur et al.* [2006], *Taylor and Mitchell* [2000], *Tewari and Seckbach* [2011], *Thakur* [1998], *Tobgay et al.* [2009], *Valdiya and Jhingran* [1973], *Valdiya* [1995], and *Wadia* [1975]	Paper map	2
Iran	*Pollastro et al.* [1997b]	*Alavi* [1994], *Alsharhan and Nairn* [1997], *Boccaletti et al.* [1976], *Farhoudi and Karig* [1977], *Fürsich et al.* [2009], *Mehrabi et al.* [1999], *Moores and Fairbridge* [1997], *Pollastro et al.* [1997b], *Seyed-Emami* [2003], and *Wendt et al.* [2005]	Shapefile	2.5
Japan	*Geological Survey of Japan* [2003]	*Geological Survey of Japan* [2003] and *Takai et al.* [1963]	Shapefile	1

Table A1. (continued)

Country (Region)	Map Sources	Lithology Sources	Original Format	Scale (1:X mil)
Korea	*CCOP* [2004]	*CCOP* [2004], *Egawa and Lee* [2009], *Kim and Lee* [1996], *Lee and Chough* [2006], *Moores and Fairbridge* [1997], and *Sim and Lee* [2006]	Shapefile	2
Laos	*CCOP* [2004]	*CCOP* [2004] and *Fromaget and Saurin* [1952]	Shapefile	2
Malaysia	*CCOP* [2004]	*Balaguru and Nichols* [2004], *CCOP* [2004], *Cocks et al.* [2005], *Heng* [1992], *Metcalfe* [1990], *Wang and Sugiyama* [2002], and *Williams et al.* [1988]	Shapefile	2
Maldives	GADM database of global administrative areas (version 1.0, 2009)	*Moores and Fairbridge* [1997]	Shapefile	1[a]
Mid East (used for Pakistan and Afghanistan)	*Haghipour and Saidi* [2010]	*Doebrich and Wahl* [2006], *Haghipour and Saidi* [2010], and *Khan et al.* [1964]	Shapefile	5
Mongolia	*Steinshouer et al.* [1999]	*Bayasgalan et al.* [2007], *Dashzeveg et al.* [1995], *Hanzl and Krejci* [2005], *Jahn et al.* [2000], *Mineral Resources Authority of Mongolia* [1998], *Steinshouer et al.* [1999], and *Traynor and Sladen* [1995]	Shapefile	5
Myanmar	*CCOP* [2004]	*CCOP* [2004], *Earth Sciences Research Division* [1977], *Helmcke* [1985], *Khin and Myitta* [1999], *Latt et al.* [2008], *Loveman* [1919], *Mitchell* [1992], and Myanmar Ministry of Science and Technology (Sample questions and worked out examples for Geol-03042 Engineering Geology for Mining Engineering, 2010)	Shapefile	2
Sri Lanka	*Economic and Social Commission for Asia and the Pacific* [1989]	*Economic and Social Commission for Asia and the Pacific* [1989]	Shapefile	1
South Asia (used for parts of Nepal and Bhutan)	*Wandrey and Law* [1998]	*Castelli and Lombardo* [1988], *Corrie and Kohn* [2011], *Corvinus and Rimal* [2001], *Dietrich and Gansser* [1981], *Long et al.* [2011], *Rai et al.* [2007], and *Wandrey and Law* [1998]	Shapefile	10
Soviet Union (former)	*Karpinsky* [1983]	*Dolginow et al.* [1994], *Karpinsky* [1983], and *Zhamojda* [1968]	Paper map	2.5
Thailand	*CCOP* [2004]	*CCOP* [2004] and *Dheeradilok et al.* [1992]	Shapefile	2
Turkey	*Institute of Mineral Research and Exploration* [1961]	*Institute of Mineral Research and Exploration* [1961], *Okay et al.* [2002, 2008], and *Yilmaz* [1993]	Mapinfo	0.5
Vietnam	*CCOP* [2004]	*CCOP* [2004], *Fromaget and Saurin* [1952], and *Lepvrier et al.* [2011]	Shapefile	2
Yemen	*Natural Resources Project* [1990]	*Alsharhan and Nairn* [1997], *Natural Resources Project* [1990], *Purser* [1998], and *Yemen Geological Survey and Mineral Resources Board* [2009]	Shapefile	1

Table A1. (continued)

Country (Region)	Map Sources	Lithology Sources	Original Format	Scale (1:X mil)
		Australasia		
Queensland	*Whitaker et al.* [2007]	*Whitaker et al.* [2007]	Shapefile	1
New South Wales	*Raymond et al.* [2007c]	*Raymond et al.* [2007c]	Shapefile	1
Victoria	*Raymond et al.* [2007b]	*Raymond et al.* [2007b]	Shapefile	1
Tasmania	*Raymond et al.* [2007a]	*Raymond et al.* [2007a]	Shapefile	1
South Australia	*Whitaker et al.* [2008]	*Whitaker et al.* [2008]	Shapefile	1
Western Australia	*Stewart et al.* [2008]	*Stewart et al.* [2008]	Shapefile	1
Northern Territory	*Liu et al.* [2006]	*Liu et al.* [2006]	Shapefile	1
Brunei	*CCOP* [2004]	*CCOP* [2004] and *Heng* [1992]	Shapefile	2
Fiji	*Colley* [1976]	*Bradshaw* [1992], *Colley* [1976, 2009], and *Rodda* [1967]	Mapinfo	0.25
Indonesia	*Geological Survey Institute of Indonesia* [1993]	*Geological Survey Institute of Indonesia* [1993]	Shapefile	1
Malaysia Sabah	*Yin* [1985]	*Yin* [1985]	Mapinfo	0.5
Malaysia Sarawak	*Heng* [1992]	*Heng* [1992]	Mapinfo	0.5
New Caledonia	*Direction de l'Industrie, des Mines et de l'Energie* (*DIMENC*) [1981]	*DIMENC* [1981]	Shapefile	0.2
New Zealand	*New Zealand Geological Survey* [1972]	*New Zealand Geological Survey* [1972]	Shapefile	1
Papua New Guiney	*CCOP* [2004]	*CCOP* [2004] and *Stead* [1990]	Shapefile	2
Philippines	*CCOP* [2004]	*CCOP* [2004], *Mitchell et al.* [1986], and *Moores and Fairbridge* [1997]	Shapefile	2
Solomon Islands	*Steinshouer et al.* [1999] and *Turner* [1978]	*Petterson et al.* [1999] and *Turner* [1978]	Mapinfo	5 (0.1)
Vanuatu	*Mollock* [1974]	*Mollock* [1974]	Mapinfo	1
		Europe		
Austria	*Egger et al.* [1999]	*Egger et al.* [1999]	Shapefile	1.5
Balkan	*Pawlewicz et al.* [1997]	*Dinter and Royden* [1993], *Grubić* [1980], *Iancu et al.* [2005], *Pawlewicz et al.* [1997], *Robertson and Shallo* [2000], *Schefer et al.* [2011], *Sotiropoulos et al.* [2008], and *Szabó et al.* [1992]	Shapefile	5
Belgium	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)	One Geology Europe Consortium 2010	Shapefile	1
Britain	*British Geological Survery* [2007]	*Archer* [1977], *Brenchley and Rawson* [2007], *British Geological Survery* [2007], *Cook* [1995], *Cope et al.* [1992], *Cox et al.* [1992], *Crimes et al.* [1992], *Davies* [1967], *Douglas and Arkell* [1928], *Gallois and Etches* [2001], *Gallois* [1976], *Greensmith* [1957], *Hallam and Sellwood* [1976], *Tunbridge* [1981],	Shapefile	0.65

Table A1. (continued)

Country (Region)	Map Sources	Lithology Sources	Original Format	Scale (1:X mil)
		John and Fisher [1984], *Macdougall and Prentice* [1964], *Milodowski and Zalasiewicz* [1991], *Peter* [1986], *Pharaoh and Carney* [2000], *Edwards* [1976], *Rushton* [1979], *Smith and Edwards* [1991], *Watts* [1962], *Williams and Floyd* [2000], *Wright and Knight* [1995], and *Wright* [1856]		
Czech Republic	One Geology Europe Consortium 2010	One Geology Europe Consortium 2010	Shapefile	1
Denmark	One Geology Europe Consortium 2010	One Geology Europe Consortium 2010	Shapefile	1
Estonia	One Geology Europe Consortium 2010	One Geology Europe Consortium 2010	Shapefile	1
France	*Bureau de Recherches Géologiques et Minières* (*BRGM*) [2003]	*BRGM* [2003]	Shapefile	1
Germany	*Trurnit et al.* [2003]	*Trurnit et al.* [2003]	Shapefile	1
Hungary	One Geology Europe Consortium 2010	One Geology Europe Consortium 2010	Shapefile	1
Ireland	*Geological Survey of Ireland* [2006]	*Geological Survey of Ireland* [2006]	Shapefile	0.5
Italy	One Geology Europe Consortium 2010	One Geology Europe Consortium 2010	Shapefile	1
Luxemburg	One Geology Europe Consortium 2010	One Geology Europe Consortium 2010	Shapefile	1
Netherlands	One Geology Europe Consortium 2010	One Geology Europe Consortium 2010	Shapefile	1
Northern Europe	*Sigmond* [2002]	*Sigmond* [2002]	Shapefile	4
Poland	One Geology Europe Consortium 2010	One Geology Europe Consortium 2010	Shapefile	1
Portugal	One Geology Europe Consortium 2010	One Geology Europe Consortium 2010	Shapefile	1
Portugal Islands	*Billett and Cowden* [1980] and GADM database of global administrative areas (version 1.0, 2009)	*Billett and Cowden* [1980] and *Dürr et al.* [2005]	Paper map/shapefile	1
Slovak Republic	One Geology Europe Consortium 2010	One Geology Europe Consortium 2010	Shapefile	1
Slovenia	One Geology Europe Consortium 2010	One Geology Europe Consortium 2010	Shapefile	1
(former) Soviet Union	*Karpinsky* [1983]	*Dolginow et al.* [1994], *Karpinsky* [1983], and *Zhamojda* [1968]	Paper map	2.5
Spain	*Instituto Geológico y Minero de Espana* [1994]	*Instituto Geológico y Minero de Espana* [1994]	Shapefile	1
Sweden Gotland	*Pawlewicz et al.* [1997]	*Manten* [1971]	Shapefile	5
Switzerland	*Bundesamt für Landestopografie* [2005]	*Bundesamt für Landestopografie* [2005], *Hsü and Briegel* [1991], *Walter* [1995], and *Weissert and Stössel* [2010]	Shapefile	0.5
		North America		
Alaska	*Moll et al.* [1997]	*Beikman* [1980]	Shapefile	2.5
Canada	*Wheeler et al.* [1997]	*Fyffe and Richard* [2007], *Ludington et al.* [2005], *Ministère des Ressources Naturelles* [2002], *Nicholson et al.* [2006], and *Wheeler et al.* [1997]	Shapefile	5
Canada - Alberta	*Hamilton et al.* [2004]	*Buschkuehle* [2003], *Douglas et al.* [1974, 1970], *Frazier and Schwimmer* [1987], *Hamblin* [1997], *Hamilton et al.* [2004], *Hayes et al.* [1994],	Shapefile	1

Table A1. (continued)

Country (Region)	Map Sources	Lithology Sources	Original Format	Scale (1:X mil)
		Irish [1971], *Macdonald and Slimmon* [1999], *Massey et al.* [2005], *McMechan and Dawson* [1995], *Okulitch* [2006], *Ollerenshaw* [1970], *Pollock et al.* [2000], *Powers* [1931], *Pruett and Murray* [1991], *Richardson et al.* [1990], and *Yeo et al.* [2002]		
Canada – Baffin Island	*Scott and de Kemp* [1998]	*Blackadar et al.* [1968], *Johns and Young* [2006], and *Scott and de Kemp* [1998]	Shapefile	1
Canada – British Columbia	*Massey et al.* [2005]	*Massey et al.* [2005]	Shapefile	0.25
Canada - Manitoba	*Schledewitz and Lindal* [2005]	*Schledewitz and Lindal* [2005]	Shapefile	0.25
Canada - Newfoundland	*Colman-Sadd and Crisby-Whittle* [2005]	*Colman-Sadd and Crisby-Whittle* [2005]	Shapefile	0.1
Canada – North West Territories	*Irwin* [2005]	*Irwin* [2005]	Shapefile	0.5
Canada Nova Scotia	*Fisher and Poole* [2006]	*Fisher and Poole* [2006]	Shapefile	0.5
Canada - Ontario	*Ontario Geological Survey* [1993]	*Ontario Geological Survey* [1993]	Shapefile	1
Canada - Saskatchewan	*Macdonald and Slimmon* [1999]	*Douglas et al.* [1970], *Fuzesy* [1979], *Gendzwill and Metieshin* [1996], *Hartlaub et al.* [2004], *Macdonald and Slimmon* [1999], *Marsh and Heinemann* [2006], and *Millard* [1996]	Shapefile	1
Canada – Slave Province	*Stubley* [2005]	*Stubley* [2005]	Shapefile	0.1
Canada – Western Churchill	*Paul et al.* [2002]	*Aspler and Chiarenzelli* [1997], *Ernst and Buchan* [2004] *Hadlari and Rainbird* [2000], *Hadlari et al.* [2006], *Paul et al.* [2002], *Schau* [1993], and *Tella et al.* [2007]	Shapefile	1
Canada Yukon	*Gordey and Makepeace* [2000]	*Gordey and Makepeace* [2000]	Shapefile	0.25
Conterminous USA	*Dicken et al.* [2005, 2007], *Ludington et al.* [2005], *Nicholson et al.* [2005, 2006, 2007], and *Stoeser et al.* [2005]	*Dicken et al.* [2005, 2007], *Ludington et al.* [2005], *Nicholson et al.* [2005, 2006, 2007], and *Stoeser et al.* [2005]	Shapefile	0.5
Costa Rica	*Schruben* [1996]	*Schruben* [1996]	Shapefile	0.5
Greenland	*Escher and Pulvertaft* [1995]	*Escher and Pulvertaft* [1995] and *Henriksen et al.* [2009]	Shapefile	2.5
Honduras	*Wieczorek et al.* [1998]	*Wieczorek et al.* [1998]	Shapefile	0.5
Mexico	*Servicio Geologico Mexicano* [2007]	*Servicio Geologico Mexicano* [2007]	Shapefile	0.5
Middle America General	*Garrity and Soller* [2009]	*Alminas et al.* [1994], *Arengi and Hodgson* [2000], *Brown* [1913], *Brunt et al.* [1973], *Bureau des Mines et de l'Energie* [1988], *Candanedo et al.* [1998], *Christman* [1953], *Draper et al.* [1994, 1996], *Frank et al.* [1998], *Gallienne* [1975], *Garrity and Soller* [2009], *Geological Survey Department Jamaica* [1958], *Gunawan et al.* [2008], *James and Ginsburg* [1979], *Kesler et al.* [1977], *Llinas* [2005], *Mesolella*	Shapefile	5

Table A1. (continued)

Country (Region)	Map Sources	Lithology Sources	Original Format	Scale (1:X mil)
		et al. [1969], *Ministerio de Medio Ambiente y Recursos Naturales* [2002], *Mylroie and Carew* [1995], *Palmer* [1945], *Schruben* [1996], *Servicio Geologico Mexicano* [2007], and *Wieczorek et al.* [1998]		
Puerto Rico	*Bawiec* [1999]	*Bawiec* [1999]	Shapefile	0.1
USA Hawaii	*Sherrod et al.* [2007]	*Sherrod et al.* [2007]	Shapefile	0.1
		South America		
Argentina	*Servicio Geologico Minero Argentino* [1997]	*Servicio Geologico Minero Argentino* [1997]	Map Info	2.5
Brazil	*Serviço Geológico do Brasil* [2004]	*Serviço Geológico do Brasil* [2004]	Shapefile	1
Bolivia	*Paraeija and Ballon* [1978]	*Paraeija and Ballon* [1978]	MapInfo file	1
Chile	*Servicio Nacional de Geología y Minería* [2004]	*Servicio Nacional de Geología y Minería* [2002, 2004]	Shapefile	1
Colombia	*Gómez et al.* [2007]	*Gómez et al.* [2007]	Paper map	2.8
Ecuador	*Ortega et al.* [1982]	*Ortega et al.* [1982]	Paper map	1
French Guyana	*BRGM* [2001]	*BRGM* [2001] and *Ledru et al.* [1994]	Shapefile	0.5
Guyana & Suriname	*Schobbenhaus and Bellizia* [2001]	*Prasad* [1983] and *Schobbenhaus and Bellizia* [2001]	Shapefile	5
Paraguay	*González* [2000]	*Berrocal and Fernandes* [1996], *Comin-Chiaramonti et al.* [1999], *Gomes et al.* [1996], and *González* [2000]	Pixel image	2.5
Peru	*Instituto de Geologia y Mineria* [1975]	*Anderson* [1944], *Bahlburg et al.* [2006], *Bendezú and Fontboté* [2002], *Boucot et al.* [1980], *Bush et al.* [1994], *Callot et al.* [2008], *Campbell et al.* [2006], *Carlotto et al.* [2009], *Carrascal-Miranda and Suarez-Ruiz* [2004], *Chen et al.* [2010], *Clark et al.* [1990], *DeVries* [1988], *Fildani et al.* [2005], *Frizzell* [1943], *Haeberlin et al.* [2004], *Hillebrandt* [1970], *Instituto de Geologia y Mineria* [1975], *Jacay and Sempere* [2005], *Jacay et al.* [2008], *Jaillard et al.* [2005], *Ligarda et al.* [1993], *Lindell et al.* [2010], *Mathalone and Montoya* [1995], *Mégard and Philip* [1976], *Mégard et al.* [1984], *Noble et al.* [1974, 1979, 1990], *Petersen et al.* [1977], *Portugal* [1974], *Ramirez and Cisneros* [2007], *Riccardi et al.* [1992], *Rod and Maync* [1954], *Sandeman et al.* [1996], *Szekely* [1966], *Taylor et al.* [1998],	Shapefiles	1

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Table A1. (continued)

Country (Region)	Map Sources	Lithology Sources	Original Format	Scale (1:X mil)
		Tosdal et al. [1981], *Tsuchi* [1990], *Wilson* [1963], *Winkler et al.* [2005], and *Zapata et al.* [2005]		
Trinidad and Tobago	*Schobbenhaus and Bellizia* [2001]	*Snoke* [2001]	Shapefile	5
Uruguay	*Dirección Nacional de Minería y Geología* [1985]	*Anton* [1993], *Collazo Carabello* [2006], *Dirección Nacional de Minería y Geología* [1985], *Lustrino et al.* [2005], *Manganelli et al.* [2007], *Martínez and Rojas* [2004], *Masquelin et al.* [2009], *Muzio et al.* [2009], *Preciozzi Porta* [1993], *Richards* [1974], *Tófalo and Morrás* [2009], *Tófalo and Pazos* [2010], *Ubilla et al.* [2004], *Verde and Martínez* [2004], and *Veroslavsky and Ubilla* [2007]	PDF File	0.5
Venezuela	*Garrity et al.* [2006]	*Garrity et al.* [2006]	Shapefile	0.75

[a]No geological map was available for these islands, thus other available spatial representations were used and given a homogenous lithology.

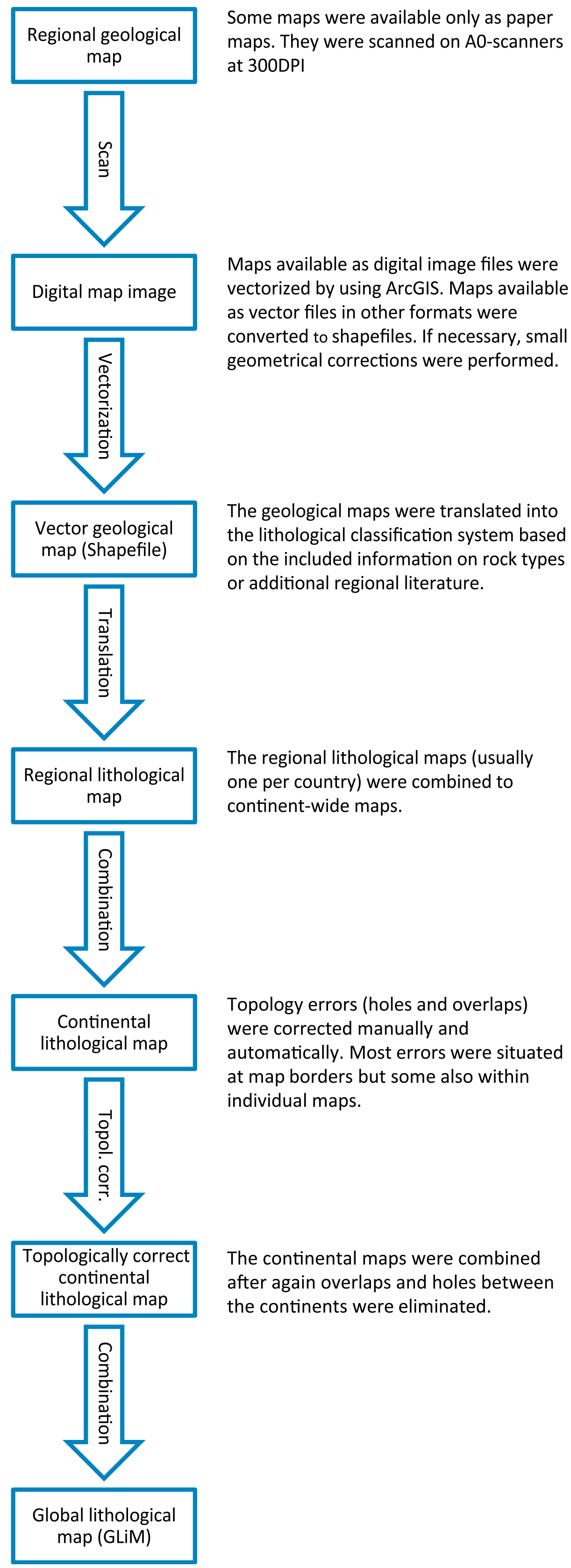

Figure A1. Simplified workflow of the GLiM development.

The geological map of Antarctica [*Tingey*, 1991a] did not include ice areas. The Antarctic digital database (Scientific Committee on Antarctic Research, Antarctic digital database, 2012) was used to represent the ice extent around the geological units.

[29] A few island areas had no geological maps even after intensive research. However, these were all volcanic or carbonate islands. Thus, their shape was taken from administrative data sets, and a uniform lithology was assumed, based on geological literature. Affected areas are: Azores, Cape Verde Islands, Maldives.

[30] In order to build a topologically sound data set, the regional national geological maps were not simply all combined into one map, but their shapes adapted to perfectly match on a per-continent basis.

[31] First, the parts of geological maps which were overlapping with their neighbors were erased (GIS tool), favoring 1) maps of higher resolution and 2) more trusted maps (e.g., available in better format or with more concise description). The erase order per continent is given below. Maps named first were given preference to those named afterwards. If the erased map had greater terrestrial coverage than the favored map, the resulting fragments were deleted manually.

[32] *Africa*. South Africa, Namibia, Mozambique, USGS Africa.

[33] *Asia*. China Neii Mongol, China Xinjiang, Japan, China, Korea, Vietnam, Laos, Cambodia, Thailand, Malaysia, Himalaya, Sri Lanka, India, Myanmar, Bangladesh, South Asia, Yemen, Turkey, former Soviet Union, Iran, Arab Peninsula, Mid East, Mongolia, Maldives, Andaman Islands.

[34] *Antarctica*. No classical border conflicts were encountered in Antarctica. However, the geological map, which did not represent ice areas, was erased from a map representing those areas.

[35] *Australia and Oceania*. Australia-NSW, Australia-NT, Australia-QLD, Australia-SA, Australia-TAS, Australia-VIC, Australia-WA, Malaysia Sabah, Malaysia Sarawak, Brunei, Papua New Guinea, Indonesia, Solomon Islands Shortland, Solomon Islands general.

[36] *Europe*. Ireland, Britain, Spain, Portugal, Portugal Islands, Luxemburg, Belgium, Italy, Netherlands, France, Denmark, Poland, Switzerland, Slovenia, Slovakia, Czech Republic, Hungary, Austria, Germany, Estonia, Sweden Gotland, Balkan USGS, North Europe, European part of the GLiM Asia (which is then eliminated there).

[37] *North America*. Conterminous U.S., North Part, South Part.

[38] 1. Conterminous U.S.: All maps of the conterminous U.S. were trusted on the same level, and overlaps were so small that they were not erased of each other, but converted into blank features, which then were automatically merged (ArcGIS tool "Eliminate") to the neighboring feature with the longest common border.

[39] 2. North Part: Yukon, Alaska, British Columbia, Alberta, Saskatchewan, Ontario, Manitoba, Nova Scotia, Newfoundland, Slave Province, Western Churchill, Baffin Island, Northwest Territories, Canada.

[40] 3. South Part: The south part of the North American map does not contain border conflicts between regional maps, but all parts of the geological map of North America were deleted by hand which overlapped regional maps in this region.

[41] *South America*. Brazil, French Guyana, Venezuela, Guyana, Suriname, Trinidad and Tobago, Ecuador, Chile, Peru, Colombia, Bolivia, Uruguay, Argentina, Paraguay.

[42] Following the erase procedure deleting overlapping polygons, the maps were joined with the translation tables containing the regional lithology translations (see section A3) and merged to a continental map. However, this continental map still contained numerous topological errors, mainly overlaps within individual regional maps or gaps at map borders. These were now solved by hand using the topology tools of ArcGIS. If during topology works polygons were generated whose size fell below the cluster limit of the geodatabase (of 0.1 m) and thus became zero, these polygons were deleted.

[43] The topological errors were distinguished into minor and major errors. Minor errors were small (usually smaller than 10 km^2, on average they were smaller than 1 km^2) and induced no bias. However, if a smaller unit was completely covered by a larger unit, this was classified a major error, as everything else that was not a minor error. Minor topological errors were treated automatically, as there were more than 120,000 of them. Thus manual solving was not reasonable. Each minor gap and each minor overlap was converted into a blank feature, which then was automatically merged (using the ArcGIS tool "Eliminate") to the neighboring feature with the longest border. The effects of the automatic procedure were visually checked against the original data at some locations, where it induced no

major inconsistencies (as expected for these very small features).

[44] The major errors were treated manually according to their cause. Most of these treatments are listed below:

[45] *Africa*. In Mozambique, two smaller units were overlain by a larger polygon in the original data. This was resolved by erasing their shapes from the overlapping polygon.

[46] *Antarctica*. No major topological problems were encountered in Antarctica.

[47] *Asia*. (1) Four major overlaps in China Neij Mongol, were solved favoring the smaller polygon, which would otherwise have been erased. (2) Five small islands in the Pacific were deleted that had no defined lithology and did not border to any known lithology. (3) The geological map of the former Soviet Union had been digitized by hand by student assistants. Many small topology errors were introduced by this procedure, which were treated separately before the Soviet Union map was included in the Asian map. Some major overlaps also occurred, which were solved favoring the smaller units to avoid their deletion. The reference scale of the map was reduced from 1:2.5 million originally to 1:3 million because of possible errors in digitalization.

[48] *Australia and Oceania*. (1) Several map-internal overlaps, particularly in Indonesia, between nearly identical rocks were solved manually. (2) In Indonesia, some gaps were relabeled as water bodies after visual inspection of satellite imagery.

[49] *Europe*. Particularly in Belgium, many topographical errors existed. Major errors were treated by hand. However, about 90,000 small overlaps and gaps were treated automatically. This may have caused some flaws in the representation of the Belgian geology.

[50] *North America*. (1) In the geological map of Canada, some duplicate polygons (i.e., a situation where two exactly the same polygons overlap) were resolved by deleting one of them. (2) In Hawaii, Mexico, Ontario and Saskatchewan, some smaller units were covered with larger ones. Their shapes were cut from the larger to resolve the overlap. (3) In Mexico, two major areas overlapped. One was a duplicate polygon with exactly the same attributes; the other overlap was by two polygons sharing the same geometry but classified as either basalt or alluvial. The alluvial was preferred, because of the polygon shape. (4) In Puerto Rico, a swamp classed polygon overlaps a number of other smaller units, which were cut from the larger polygon to retain them. Also one water polygon overlapped another polygon, which was favored because satellite imagery did not show water at that position.

[51] *South America*. (1) The 100 largest of the automatically filled gaps were manually checked if they were water bodies, using satellite imagery (MS Bing), and labeled accordingly. Approximately half of the polygons were water bodies. (2) 29 small holes (originally treated as minor errors) had to be merged with a neighboring polygon by hand because they caused errors when merged to their nearest neighbor automatically (actually the automatic procedure erroneously erased the nearest neighbor and themselves in the process likely due to an internal error in ArcGIS). In these cases, a new polygon was created (using the edit tool "Auto Complete Polygon") and merged to the subjectively best suited neighbor.

[52] Finally, border conflicts between the continental maps were solved based on the time of finalization. Continental maps finalized earlier were favored over those finished later. The order was: South America, North America, Africa, Asia, and Europe. Australia and Oceania had no conflicts which needed to be resolved.

A3. Lithological Translation Methods

[53] The translation from stratigraphic units provided by most of the geological maps to lithological units required two steps: First, the rock types associated with the stratigraphic unit were identified; second, this detailed information was translated into the general classes applied here.

[54] Ideally, the rock type information was already provided by the geological map data sets as an additional attribute. In this case that information was used and translated. The depth of the detail of rock description varies largely between maps, however. For example, the U.S. State maps provide major and minor rock types (maximum two rock types and standardized names), while the Australian regional maps provide a detailed description of all rocks occurring within the respective unit, often more than 250 characters long. The geological map of China and the former Soviet Union provided rock type information only in their native languages. These were translated to English by graduate assistants fluent in these languages.

[55] If the geological maps did not provide any information on rock types, descriptions of the

Table A2. List of the Lithological Classes and Subclasses in the Three Levels

Code	Description
	Level 1: xx
su	Unconsolidated sediments
ss	Siliciclastic sedimentary rocks
py	Pyroclastics
sm	Mixed sedimentary rocks
sc	Carbonate sedimentary rocks
ev	Evaporites
va	Acid volcanic rocks
vi	Intermediate volcanic rocks
vb	Basic volcanic rocks
pa	Acid plutonic rocks
pi	Intermediate plutonic rocks
pb	Basic plutonic rocks
mt	Metamorphics
wb	Water Bodies
ig	Ice and Glaciers
nd	No Data
	Second Level: yy
ad	Alluvial deposits
ds	Dune sands
lo	Loess
la	Laterites
or	Organic sediment
mx	Mixed grain size
sh	Fine grained
ss	Coarse grained
am	Mafic metamorphics mentioned
gr	Greenstone mentioned
pu	(Pure) carbonate
py	Pyroclastics mentioned
	Third Level: zz
bs	Black shale mentioned
cl	Fossil plant organic material mentioned
ch	Chert mentioned
fe	Iron minerals mentioned
ph	Phosphorous-rich minerals mentioned
pt	Pyrite mentioned
gl	Glacial influence mentioned
mt	Metamorphic influence mentioned
ev	Subordinate evaporites mentioned
vr	Subordinate volcanics mentioned
pr	Subordinate plutonics mentioned
sr	Subordinate sedimentary rocks mentioned
su	Subordinate unconsolidated sediments mentioned
we	Intensive weathering mentioned

named stratigraphic units were sought in regional literature. The quality of the literature was variable and may have introduced some uncertainty. In some rare locations, the rock type information of digital geological map vector data sets was derived from paper maps, which were georeferenced and visually assigned to the units of the digital maps.

[56] The different rock type information was translated into the lithological classes listed below, usually emphasizing more reactive rock types. However, determining the dominant rock types within a unit was not always straightforward. In accordance with abundant mapping guidelines it was assumed that rocks mentioned foremost are more abundant than those mentioned later in rock unit descriptions. In some cases combinations of certain rock types led to a specific classification. Technically, all translations were done in a join-table, which combined the attribute of the geological map that the join was based upon (usually defining the stratigraphic unit), with the rock description, lithology class, age, source and quality information as well as additional comments. In very few cases, two stratigraphic units were given different (but similar) rock compositions in the source map. In this case, only one of the different compositions was used for translation. Affected Regions where this occurred include British Columbia, Manitoba, Nova Scotia and Yukon in Canada. The same process was applied where the age attribute differed, where e.g., three units in British Columbia had two different ages assigned, of which only the first was used.

A4. The Lithological Classification

[57] The lithological classification is an extension of the classification system by *Dürr et al.* [2005], with additional classes and two new levels of information [cf. *Jansen et al.*, 2010; *Moosdorf et al.*, 2010]. The lithological classification is now represented by a six-symbol code: “xxyyzz,” where “xx” represents the code of the first level information, comparable to the existing lithological nomenclature. In addition, “yy” gives more detailed information on rock types, while “zz” provides special information about the mapped unit. The second and third level information is optional, and not all units provide additional information (represented by the code “__”). This structure reduces information to few general classes but has additional detail information when needed and available. Table A2 lists all lithological classes and subclasses.

A4.1. First Level: xx

[58] The first level lithological class was mandatory for all units. It describes the general rock types in the mapped unit.

A4.1.1. Siliciclastic Sediments (su, ss, py)

[59] *Unconsolidated sediment (su)* represents young, not yet consolidated sediments, usually of Cenozoic age. It comprises all grain sizes, which are indicated by the second level information.

Additionally, more specific unconsolidated sediments can be indicated there, i.e., dune sands, alluvial deposits, loess and swamps. Examples of unconsolidated sediments are sands, mud, swamp deposits, dunes, and beach sands. Where carbonate is reported in the unconsolidated sediment, the lithological class sm (see below for description) is usually selected, thus losing the information on the consolidation, but maintaining the information on the carbonate content.

[60] *Siliciclastic sedimentary rocks (ss)* represent e.g., sandstone, mudstone and greywacke, but may also show a small degree of metamorphic alteration (e.g., shale; this would be indicated by the third level information mt). Siliciclastic sediment is usually accompanied by the second level information of grain size. Where carbonate was named in the rock description of the mapped unit, the lithological unit sm was used, so siliciclastic sedimentary rocks are without mapped carbonate influence. Note that in some cases the carbonate presence (e.g., as matrix) may not be named in the rock description, and siliciclastic sediments may still contain carbonate in reality.

[61] *Pyroclastics (py)* are sediments of volcanic origin. Typical pyroclastics are tuff, volcanic breccias, or ash. If a unit appears to be dominated by pyroclastics, its first level information was set to py. However, if only smaller amounts of pyroclastics are described in the rock description, instead the second level information can be set to py.

A4.1.2. Carbonate-Rich Sedimentary Rocks and Evaporites (sc, sm, ev)

[62] *Mixed sedimentary rocks (sm)* represent all sediments where carbonate is mentioned but not dominant, plus some units that were identified as sediments, but no information on the type of sediment was available. Mixed sedimentary rocks are usually a combination of different rock types (e.g., interlayered sandstone and limestone). Another classical representative rock of that class would be e.g., shaley marl. The class sm is usually accompanied by the second level information of the grain size of its siliciclastic fraction. Sediments classed as sm may in some cases also be unconsolidated, in which case the information on the carbonate content was retained rather than the information on the consolidation state.

[63] *Carbonate sedimentary rocks (sc)* are dominated by carbonate rocks. Examples of sc units are limestone, dolomite and marl. As usually the rock descriptions of the mapped units do not give relative abundances of the rock types which they encompass, units were classed as sc if the first named rock type was a carbonate rock, if the majority of rock types were carbonates or if the named order otherwise led to the impression of a domination by carbonates. If siliciclastic sediments were mentioned in a carbonate-dominated unit, the grain size of the siliciclastic fraction is usually given in the second information level. If that was not the case, the second level code "pu" indicates the unit as a pure carbonate.

[64] *Evaporite (ev)* units contain substantial amounts of evaporitic rocks. The typical encountered evaporite rock was gypsum, but also anhydrite, halite or nomenclatures as "salt pan." If a map unit was interpreted as dominated by evaporites, it was classed as ev, regardless of other mentioned rocks. This implies, that ev units may additionally contain, e.g., carbonates. This would usually be indicated by the available subclasses.

A4.1.3. Volcanics (va, vi, vb)

[65] Volcanic rocks are divided in three main lithological classes, based on their composition.

[66] *Acid volcanics (va)* are typically rhyolites, trachytes or dacites and classed after *Le Maitre* [2004].

[67] *Intermediate volcanics (vi)* are classically andesites. However, if basic or acid volcanics are mentioned in addition to intermediate volcanics, then the former classes are selected. Units featuring only acid and basic volcanics or, rarely, volcanics of unknown type are also classed as intermediate volcanics.

[68] *Basic volcanics (vb)* are usually basalt-type rocks. Rock types classified as basic volcanics (following *Le Maitre* [2004]) apart from basalts are e.g., tephrites, tholeites, and lamprophyres.

A4.1.4. Plutonics (pa, pi, pb)

[69] *Acid plutonics (pa)* represent plutonic rocks containing quartz. Granites and their relatives are grouped in this class in particular, but also quartz-diorites and quartz-monzonites. In addition, there is an overlap with the metamorphic rocks, as some migmatites may also be referred to as granite in the geological maps, so would be classed as pa, as would granitic gneiss, or slightly folded granite. Although these are strictly metamorphic rocks in that they experienced metamorphosis, but their

attributes are likely to be more related to the acid plutonics than to some of the members of the very heterogeneous group of metamorphic rocks.

[70] *Intermediate plutonics (pi)* encompass a group of non-mafic plutonic rock types mainly defined by their 'relative' absence of quartz. This class is dominated by diorite, monzonite, syenite and their subtypes. In addition, this class was used in the few cases in which no clear character of a mapped plutonic rock could be identified.

[71] *Basic plutonics (pb)* include plutonic rocks rich in mafic minerals, like gabbro and peridotite, as well as ultrabasic species like norite. Ophiolite structures would be classified as basic plutonic. Basic plutonic rocks can, like their acid and intermediate counterparts, show a certain degree of metamorphism but still be classified as basic plutonic.

A4.1.5. Metamorphics (mt)

[72] *Metamorphics (mt)* is the 'broadest' lithological class. It encompasses a wide variety of rocks from shales to gneiss, from amphibolite to quartzite. If the metamorphics contain marble, they were assigned the yy attribute 'pu', indicating the presence of carbonate outside sc or sm units. If they contained mafic metamorphic rocks (e.g., amphibolite), the yy-attribute was set to 'am'. If the metamorphism seemed only weak, the original rock was used to define the lithological class. For example the rock description "foliated, slightly folded granite" triggered classification as acid plutonic rock (xx = pa), accompanied by a zz-value of 'mt', indicating a metamorphosis of the rock.

A4.1.6. Other Units (wb, ig, nd)

[73] *Water bodies (wb)* were included although not a rock type. Some geological maps either include water bodies as a geological unit or leave the water covered areas blank, leading to gaps in the digital data set. Such areas are classed as water bodies here. They encompass lakes, rivers, but also parts of some coastal oceans. The water body areas are not meant to be used as indication of water areas in general, as they are not a priority of this data set. Here, lithology is prioritized, but if the geological map had water as 'rock type', 'water bodies' was assigned.

[74] *Ice and glaciers (ig)* are mainly situated in Antarctica, Greenland and on some mountains. However, the coverage is not representative for an ice extent, as the priority of this map is on lithology. If the source geological maps identified ice, then class ig was used. The only exception is Antarctica, where the geological map did not represent ice areas and an independent data set was used for their representation.

[75] *Non-defined (nd)* units are blank areas of the map. Although much effort was put into representing all areas of the globe, the rock types of some units could not be identified and are classed as non-defined. Most are classed as undefined in the source geological maps. A significant proportion of these units seems to be situated under glaciers.

A4.2. Second Level: yy

[76] The second level lithological information was introduced to further describe the mapped rocks where possible and appropriate. Information of this level can be combined with the first level to adapt the classification to answer specific questions. However, contrary to the first level information, the second and third level information is not mandatory and has not been assigned in all cases.

A4.2.1. Specific Unconsolidated Sediments (ad, ds, la, lo, or)

[77] Some specific unconsolidated sedimentary units were dealt with separately because of their specific attributes, composition or genesis.

[78] *Alluvial deposits (ad)* are very young sediments associated with fluvial systems. They are mapped if the original map referred to alluvial units, e.g., alluvial fans or terraces. However, their representation in the different maps is very variable, because many geological maps do not differentiate unconsolidated units.

[79] *Dune sands (ds)* are aeolian sediments, occurring mostly at beaches or in deserts. Again, their representation is incomplete, as many geological maps did not contain this information.

[80] *Laterites (la)* were included if deeply weathered soils are described in the source literature. As the reference depth for the GLiM cannot be consistent, the subclass la indicates a thick weathered soil horizon above the rocks defining the lithological class.

[81] *Loess (lo)* is an aeolian sediment deposited during glacial times. However, the representation of loess is complicated, as it is often only a thin cover, which is ignored by the geological maps. No additional sources were used for this attribute, thus its coverage, compared to specialized maps focusing loess cover [e.g., *Bettis et al.*, 2003; *Haase et al.*, 2007; *Pécsi*, 1990; *Zárate*, 2003], is very restricted.

[82] *Organic sediment (or)* is mapped if the geological map mentions swamp deposits. Organic sediment has a very specific environment, which can be important for numerous applications. However, again, not all swamps were identified in the map, as no additional sources apart from the geological maps were used.

A4.2.2. Sediment Grain Sizes (mx, sh, ss)

[83] If it was possible to define a dominating grain size in siliciclastic sediments, this was indicated by a second level attribute. These attributes were added to consolidated and unconsolidated sedimentary lithology classes.

[84] *Mixed grain sizes (mx)* indicate the lack of a dominating grain size, or the absence of grain size information.

[85] *Fine grains (sh)* indicate a dominance of grains finer than sand.

[86] *Coarse grains (ss)* indicate a dominating grain size of at least sand diameter.

A4.2.3. Metamorphic Rocks (am, gr)

[87] The lithological class of metamorphic rocks encompasses a multitude of different rock types. The reference to some specific metamorphic rocks resulted in the assignation of a second level attribute, even in cases of non-metamorphic lithological classes (e.g., plutonic dominated units).

[88] *Mafic metamorphic rocks (am)* are classed if rocks like amphibolite or serpentinite are indicated in the geological units. Amphibolites, for instance, have weathering rates that are about four times higher than gneiss [*Meybeck*, 1987] and are thus highlighted by this attribute.

[89] *Greenstones (gr)* are mapped to highlight their presence. The greenstone belts are old and complex structures and may thus be of interest for a number of applications. However, not all greenstone belts are represented in the lithological map, only those indicated by their source maps. Thus gr should not be used as a comprehensive reference of the occurrence of global greenstone.

A4.2.4. Carbonate and Pyroclastics Occurrence (pu, py)

[90] *Pure carbonate rocks (pu)* was intended to indicate sc, pure carbonate units without siliciclastic contents. However, the pu-attribute is also used in non-sedimentary units to indicate minor carbonate occurrences that are not sufficient enough to justify setting the first level to sc.

[91] *Pyroclastic sediments (py)* can also be attributed in the second level. In contrast to the first level py, the second level attribute indicates some occurrences of pyroclastics rather than the dominant rock type of the mapped unit. This subclass is a recognition of the potential importance of the presence of pyroclastics, which was reported to exhibit very high weathering rates when fresh [*Dahlgren et al.*, 1999; *Hartmann et al.*, 2010].

A4.3. Third Level: zz

[92] The third level adds information on individual aspects of the rocks and other mapped rock types, if available. Again, the third level information is neither mandatory nor exhaustive. The absence of third level information does not necessarily indicate the absence of the associated rock attribute. However, the presence of a third level zz-code clearly indicates the presence of the respective rock attribute.

A4.3.1. Fossil Carbon Rich Sediments (bs, cl)

[93] The occurrence of fossil carbon rich sediments can be relevant for some scientific questions, like the quantification of processes in the carbon cycle [*Copard et al.*, 2007].

[94] *Black shale (bs)* is mapped where, e.g., black shale, oil shale, organic-rich shale, or similar rock units are named in the rock description.

[95] *Coal (cl)* is mapped if significant occurrences of any kinds of lignite or coal, up to anthracite, are noted in the rock description. It is often associated with siliciclastic or mixed sediment.

A4.3.2. Special Occurrences (ch, fe, ph, pt)

[96] Occurrences of certain materials in rock units, which may be interesting for individual studies are indicated by this third level attribute group. However, the latter three units are very rare and do not represent all occurrences of the materials.

[97] *Chert (ch)* occurrences are mapped individually. Example uses for chert include estimating silica exports from carbonate rock units as reported by *Jansen et al.* [2010].

[98] *Iron (fe)* is mentioned if the geological maps noted iron deposits, e.g., banded iron formations or magnetite.

[99] *Phosphorous (ph)* was noted if, e.g., phosphorite or apatite were indicated in the geological

maps or the description of the rocks. This information was added, because phosphorous is an important nutrient and thus the supply of that element to the biosphere via chemical rock weathering may be essential in many areas.

[100] *Pyrite (pt)* is occasionally noted in the geological maps or the literature describing the rocks. Pyrite weathering can be important for matter flux mass balances and impacts the pH of adjacent waters bodies.

A4.3.3. Genesis Aspects (gl, mt, we)

[101] Rock properties are of course strongly affected by their genesis which is only seldom represented in the geological maps. However, three attributes containing particular information about the rock genesis are indicated at the zz level.

[102] *Glacially overprinted units (gl)* indicate references to previous glacial activity. This encompasses directly glacial sediment, e.g., glacial till, as well as glacial overprinting in the unit description of other rock units. Again, this is in no way a complete description of all glacially affected units globally.

[103] *Metamorphic rocks (mt)* are highlighted in the third level in addition to the first level as well as the second level focusing, which focused on two certain rock types solely (yy = 'am' or 'gr'). Third level 'mt' occurs in two possible settings. If rocks are slightly metamorphosed, but their source rock was clearly named in the geologic description, e.g., foliated granite, the original rock type defined the lithological class (in this case xx = pa), and the third level information mt was added. If the properties of the slightly metamorphosed rocks are still similar to their source rocks, this procedure defines these rocks better than setting xx = mt, which would add them to the very broad group of metamorphics. For example, in order to emphasize the carbonate content, a marble would be classed scpumt (a metamorphosed pure carbonate rock). The second meaning of the third level information mt is that within the mapped units, minor occurrences of metamorphic rocks are named in a unit dominated by a rock type leading to a different first level attribute than mt.

[104] *Intensive weathering (we)* is not directly a genetic attribute of the original rock, but has altered the attributes of the rock which is now encountered in the unit where it is mapped. The subclass "we" was attributed where the source geological map indicates rocks as weathered.

A4.3.4. Minor Occurring Rock Types (ev, vr, pr, sr, su)

[105] If rock types other than the dominating rock that defines the first level lithological class are noted within a map unit, they can be added to the third level aggregated in broad rock groups.

[106] *Evaporites (ev)* define only small occurrences of evaporitic sediments. Evaporites weather very fast, and thus have a big impact on the chemistry of natural waters and are always mentioned in the lithological classification if they are mentioned in the geological maps (either as first or third level lithological information).

[107] *Volcanic rocks (vr)* highlight the mapped occurrence of minor acid, intermediate or basic volcanic rocks in a map unit of a different lithological class.

[108] *Plutonic rocks (pr)* are classed at the third level if minor occurrences of acid, intermediate or basic plutonics are noted in the geological information.

[109] *Sedimentary rocks (sr)* highlight minor sedimentary strata in the described unit. If these minor units contain mapped carbonates, the third level attribute sr is accompanied by the second level attribute pu. For example, a unit of basalt lava flows interbedded with minor limestone would be classed as vbpusr.

[110] *Unconsolidated sediments (su)* highlights a dominating unit covered with unconsolidated sediments. Unfortunately, geological maps do not follow a common rule concerning the thickness of cover necessary to map unconsolidated sediments as individual units in their own right or to note them at all. Thus, the absence of the attribute does not indicate that the mapped bedrock unit is outcropping right below the topsoil horizon, but its presence indicates that certainly a significant cover of unconsolidated sediment is situated on top of the mapped lithological class. This could be important e.g., for hydrogeological applications.

A4.4. Conflict Management

[111] The applied lithological classification system allows only one single description per level of information. This of course causes conflicts if the rock description of any mapped unit allows attribution of multiple classes. The conflicts were solved in general by selecting the class with the greatest impact on matter fluxes by chemical weathering (which was the original purpose of the map). This

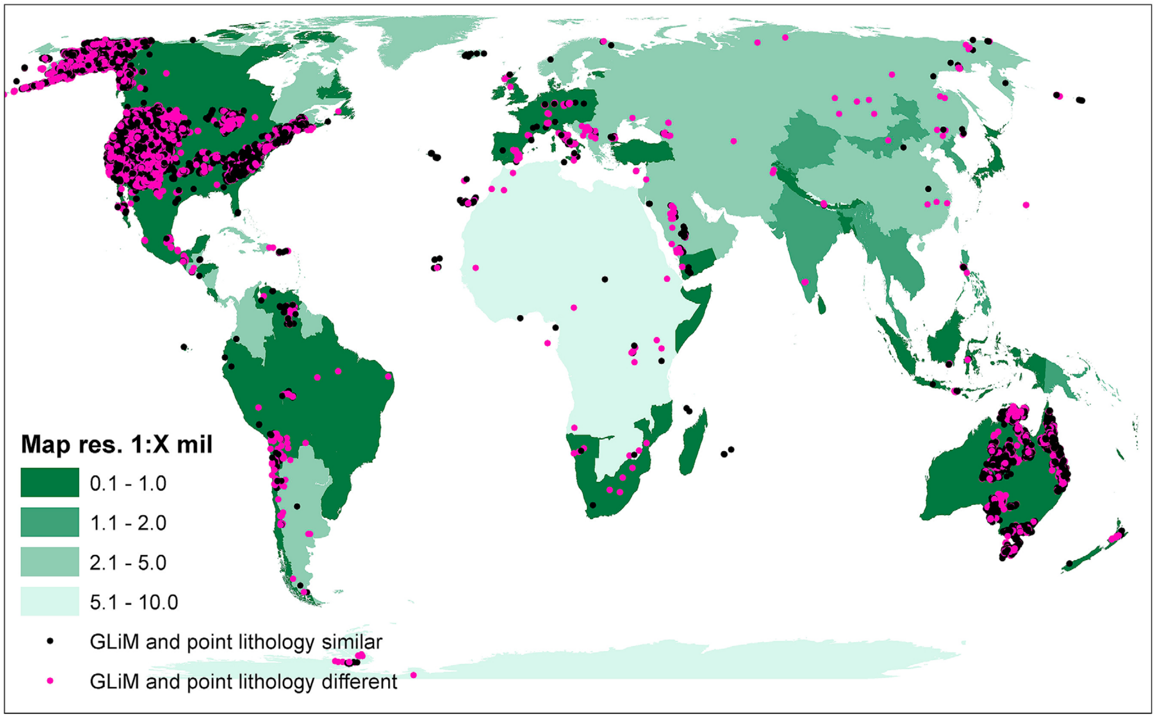

Figure A2. Spatial map quality (map resolution) and point lithology information for comparison.

leads to a general order of classification as follows (first named classes are favored above those following later): First level: ev, py, sc, vb, sm, pb, vi, va, pi, pa, su, ss, mt, wb, ig, nd; Second level: py, pu, la, am, gr, or, lo, ad, ds, sh, ss, mx; Third level: ev, ph, bs, cl, gl, fe, pt, vr, we, mt, ch, pr, su, sr.

[112] In specific cases the previously named order was changed if the rock description indicated a dominance of a minor attribute. For instance a unit mapped as swamp with very small occurrences of pyroclastics would be classed as "suor__," although the general pattern would demand to name it "supy__."

A5. Quality Classification System and Evaluation

[113] The presented global lithological map is a complex construct based on a large number of sources. To give some estimate of the reliability of the contained information at each position, a quality classification system was introduced.

[114] The spatial quality attribute 'sqa' is based on the scale of the source geological map as a metric attribute. To simplify the reading, it is defined as 'sqa' = 'source scale/10^6' (Figure A2, source scales are provided in Table A1).

[115] The applied 'thematic quality attribute' is more difficult to interpret. It contains a rating of A, B, or C to provide a broad sense of the reliability of the lithological classification. While in theory, every lithological class should correctly describe the real rock types at its location, this is more likely where the geological map directly provided the information for the lithological classification. These areas get a thematic quality attribute of "A," representing the highest reliability. If additional regional literature had to be consulted to identify the rock types associated with the stratigraphic units named in the geological source maps, the attribute "B" is given. This also applies to areas where the classification based on the geological maps was uncertain. The weakest quality, indicated by the "C" value of the attribute, indicates that only very general information about the rock types of this unit was available.

[116] However, the quality attributes were not always individually assigned to each polygon. In particular the thematic quality is only a guide to the general reliability of the information of the areas, and should be treated with care.

[117] To evaluate the accuracy of the GLIM at the point-scale, a set of 290 000 data points with rock type information was extracted from three large

databases (PetDB [*Lehnert et al.*, 2000]: www.petdb.org, SedDB: www.seddb.org, and VentDB: www.ventdb.org via the EarthChemPortal: www.earthchem.org; USGS National Geochemical Database NGDB [*U.S. Geological Survey*, 2008] and OZCHEM [*Champion et al.*, 2008]). The reported rock names were translated into lithological classes where possible and where the rock did not indicate a very local phenomena and exotic rock types (e.g., ore bodies). However, only the USGS NGDB data are outcrop data with certainty, while the others also include drill-core interpretations or surface samples. To exclude as many of these cases as possible, unconsolidated sediments were omitted from the evaluation, as well as points where the lithological map reports water, ice/glaciers or an unknown rock type. The EarthChem portal included spatial accuracy information in their data, which was restricted to data sets with an accuracy <0.01°. After the deselection processes, 164,953 points remained, of which in 40% of the cases, the lithology of the GLiM and the lithology classification of the independent sample match. This is a reasonable result when inaccuracies in the sample spatial positions are taken into account (e.g., inaccuracies of up to 10 km may occur in the OZCHEM database). If similar lithological classes are also taken into account (e.g., for mapped mixed sediments in the GLiM, the siliciclastic and carbonate lithologies of points would be accepted as "similar," or for basic or acid igneous classes also their intermediate neighbors), the match increases to 64% of the points with similar lithologies to those mapped in the GLiM (Figure A2).

A6. Contributors to GLiM

[118] Thank you to all contributors; and if anyone was forgotten in the multitude of people and organizations contributing to the map – please excuse us.

[119] The map needed extensive manual digitalization, which was done by Birte Meier (Argentina, Soviet Union, and early version Africa), Swetlana Didorenko (former USSR), Andre Paul (Austria, Colombia, Ecuador, Paraguay, Soviet Union, and Uruguay), Mercedes Pordzik (Himalaya). The rock descriptions of the geological maps of the former USSR and China had to be translated into English, which was done by Swetlana Didorenko and Yixi Gu. Some regions were translated into lithological classes as part of graduate theses by Nadja Hoppe (Eastern Australia: Queensland, New South Wales, Victoria, Tasmania), Birte Meier (early versions of Africa, South Africa), Swetlana Didorenko (Siberia) Henning Kedenburg (India) and Mercedes Pordzik (Himalaya).

[120] Several people from all over the world helped with map acquisition, which were Thomas Schlüter, Elisabeth Sillmann (Africa); James Passmore and Oliver Raymond (Antarctica); Loretta Crisby-Whittle (Newfoundland, Canada); Andrea Salas, Andreas Weiss, Caroline Raulf (Chile); Martin Schreck (Costa Rica); Jean- Paul Cadet, Philippe Rossi, CGMW (diverse maps); Rainer Lezius (India); Ana Patricia Mora Aguilar, Carlos Alcocer Valdés, Margarita Aldana (Mexico); A. Saidi (Middle East); Pavel Hanzl (Mongolia); Mark Rattenbury (New Zealand); Heiko Dirks (Arab Peninsula); Carlos Schobenhaus (South America); Arthur W. Snoke (Tobago), and Paul Hackley (Venezuela).

[121] The project ran on very limited funding and relied on mostly free access to source data. Many agencies and companies provided maps for free: Alberta Geological Survey (Alberta, Canada); BRGM (Nouvelle Caledonie, Guyane); British Columbia Ministry of Energy and Mines (British Columbia, Canada); Geological Survey of Britain (United Kingdom); CGMW (Middle East, South America, World); Cervicio Geológico do Brasil (Brazil); China Geological Survey (China); FAO (Africa); FAO Africover Project (Somalia); Geological Survey Institute of Indonesia (Indonesia); Geological Survey New Zealand (New Zealand); Geological Survey of Canada (Canada and Western Churchill, Canada); Geoscience Australia (Australia state maps); Geologische Bundesanstalt (Austria); INGEOMINAS, Colombia (Colombia); Instituto Geológico y Minero de Espana (Spain); Manitoba Geological Survey (Manitoba, Canada); Natural Resources Canada (northern Baffin Island, Canada); Newfoundland and Labrador Department of Natural Resources (Newfoundland, Canada); Northwest Territories Geoscience Office (Northwest Territories, Slave Craton, Canada); Nova Scotia Department of Natural Resources, Mineral Resources Branch (Nova Scotia, Canada); One Geology (providing links to data sources); Data from OneGeology-Europe were used and/or reproduced with the permission of the geological survey organization right holders who comprised the OneGeology-Europe project (Geological Survey of Belgium, Česká Geologická Služba, De Nationale Geologiske Undersøgelser for Danmark og Grønland, Eesti Geoloogiakeskus OÜ, Istituto Superiore per la Protezione e la Ricerca Ambientale, Geological Survey of the Netherlands, Service géologique du Luxembourg, Laboratório Nacional de Energia e

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