Areas of natural conflicts in harmonized thematic maps of the Strzelin county

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Abstract. Recently in Poland, there has been a strong emphasis on data harmonisation, which means data coherence, mainly spatial. The reason for this is the INSPIRE Directive [1] approved in 2007 and the Spatial Information Infrastructure Act [2] implemented on the basis of this Directive in Poland in 2010. On this basis, the aim of this study was to make the data from soil-agricultural maps and geological maps coherent, so that no natural conflicts would arise. The study was based on materials concerning soil classification and lithology, which are soil-agricultural and geological maps, but also on isohips. The method, which was applied, consisted in combination of attributes of the maps, then natural conflicts were identified, that is lack of smooth transition from soils to lithology - a given soil would not be able to develop on the indicated geological substratum. A significant part of the identified conflicts required editing, however some of them can be treated as exceptions. The reason for such discrepancies is the lack of precise information on the deposited layers at the depth of 1.5 m - 2.0 m, which results from the measurement methods of the analysed maps. The last step was to eliminate these conflicts in order to generate consistent and harmonised data. As a result, a list of attributes of full compatibility was obtained, thanks to them maps of any parameters can be generated, and also a basis for presenting soils in a different systematics.

1. Introduction
Data harmonisation is recently a popular topic in Polish literature, especially in the field of geodetic and cartographic databases, which still have a lack of consistency and compatibility in some areas. The actions taken towards harmonisation result directly from the obligation imposed by European Union law, namely the INSPIRE Directive [1], which was enacted in Poland as the Spatial Information Infrastructure Act in 2010 [2]. In this connection, many publications, articles, books and presentations on the harmonisation of data sets were produced. The main focus was on the coherence of spatial data from different sources, so that the whole process is carried out in a uniform and efficient way. In this article, however, we will focus on a slightly different aspect of data coherence, which will be described later in the article.

In cartography, the various environmental phenomena and relationships that occur naturally in nature are separated and presented on different thematic maps. Soils and the geological structures beneath them are an example of such relationships. In nature, soil layers are formed by the fragmentation of rocks and the accumulation of organic remains as a result of soil-forming processes. During this long process, the humus layer, soil levels and soil structure are formed. In short: from the geological structures (lithology), as a result of a very long process, soils are
formed. From this information it is therefore possible to indicate the relationship between the geological structures and the soils above them. In the research undertaken by the authors, it was decided to demonstrate the incompatibility between the attributes of soil-agricultural and geological maps and to later edit the indicated natural conflicts.

2. Related work
In recent years, an increasing number of geodata has been collected by various entities, which makes this data more common. At the same time geoinformation is gaining in significance. However, often the data is of questionable quality, we do not know its source, accuracy, measurement methods or whether it lacks metadata [3]. Thus, they are useless in professional analyses for study, planning or management of space [4]. The harmonisation of data is supposed to solve this type of problems, namely, greater data consistency.

Currently, the availability of hardware and various types of software for data processing is not a problem. Actually everyone, using open source software, can process and analyze spatial data available to the public. However, the problem is the quality of this data. The problem of data consistency and integrity is also highlighted. Data sources, methods of collecting, measuring and processing tools are different, so the data itself is also different. If the data were harmonized, then it would be possible to avoid wasting resources, and a quick analysis would also be possible to respond to some phenomena related to natural disasters. Because of the lack of consistency, the data is heterogeneous and hard to work with, and the results can sometimes be wrong. According to Villa et al., the problem is also the number of data providers, each has its own name, its own labelling system, more or less different from the others, which makes it difficult for later recipients to read and analyze the data. This is why the data can be duplicated several times [3].

Harmonized data will be the basis for creating a spatial data infrastructure that is efficient, failure-free, understandable, unambiguous and above all consistent. Not only in terms of data, but also services and tools. Great importance should be attached to cross-border data, in order to ensure its coherence and integrity across national borders. The following are indicated as the cause of data inconsistency: data format, way of data collection, data quality, reference system, conceptual model, metadata, nomenclature, detail, presentation and processing [5].

In Poland, the approach to harmonisation focuses on trying to make existing data more consistent and create a better implementation framework for new data. Kuczyńska has attempted to describe the course of the harmonisation process for the two strategies: MDA (Model Driven Architecture) and SOA (Service Oriented Architecture). The harmonisation in the concept of used models is understood as using the same categories of objects, attributes, etc. for different types of objects from different fields of geodesy and cartography. Therefore, harmonisation is understood as internal and logical consistency of application schemas. Moreover, data integration is also mentioned in terms of linking application and conceptual schemas [6].

Attention is also drawn to the problem of the quality of the data on which people work, so that the resulting data may be of questionable quality and accuracy. Ewertowski et al. pointed out these problems when analyzing planning data. Therefore, they decided to harmonize the data from the studies of conditions and directions of spatial development of several municipalities. The main problem was indicated as the labelling of divisions in the studies, which were very diverse and were characterized by different degrees of detail. It was therefore difficult to compare documents for different municipalities, for example in border areas. The authors decided to harmonize descriptive attributes for the studies in three-stage coding. On this basis, they re-coded all plans, making their designations more uniform and easier to analyze [7].

The majority of researchers focus on modifying conceptual models so that data can be harmonised. Gotlib et al. have indicated the most important tasks and steps to be taken to
harmonize data from VMap (Military Vector Map) and TBD (Topographic Database) databases. The main goal is to unify the classification of objects in both databases and the way of their visualization as well as to integrate data from both databases in order to create one coherent database to quickly create a reference database for the whole country [8]. In turn, Bac-Bronowicz et al. undertook to harmonize the BDOT10k (Topographic Objects Database in the scale 1:10 000) and BDOT500 (Topographic Objects Database in the scale 1:500), in order to supply each other with databases of different level of detail. The models of both databases have been compared and it was indicated that not all objects in the BDOT500 database have their equivalents in the BDOT10k database. Moreover, the overlapping objects are in completely different categories in particular databases. It has been suggested how to modify the databases to make them complementary to each other [9]. Modifications of conceptual models have also been proposed by Sikorska-Mayakowska and Olszewski in relation to thematic data from GUGIK (Central Office of Geodesy and Cartography) and PGI (Polish Geological Institute). The authors pointed out that currently the thematic data are presented in digital form, on a similar scale, often with similar topics, so that the user could analyse these maps together. However, due to differences in conceptual models of maps with similar issues and information contained in them, such analysis is not possible without prior detailed analysis of individual maps and instructions on how they should be made. Harmonization of these thematic maps could allow their common use and analysis [4].

The approach of integrating the developed sozological and hydrographic maps was presented by Szczepaniak-Koltun and Oberski in their work. Such a harmonisation would help to enrich the datasets of both maps by creating one map, because these datasets are complementary to each other, in one there is information that is missing in the other. Thus, their combination would allow for the creation of a complete data set. Moreover, a condensed division into thematic problems presented on the map was proposed. Harmonized maps become more accessible for analysis, because "thematic maps are supposed to be a tool for research and diagnosis of the condition of the natural environment" [10].

In turn, Kroczak et al. drew attention to the lack of data harmonisation within the natural river basins, which are at the same time divided by administrative boundaries, what makes water resources management difficult. It was decided to undertake the study using the available data in both countries. The data resources were not homogeneous. In the EU there are fairly uniform systems, but at the border with non-EU countries these data are different, with different structure, detail, range and methods of extraction. It is noted that research in cross-border areas is extremely difficult and requires above all data consistency and comparability [11].

Table 1 presents a summary of the literature together with the understanding of harmonisation.

### 3. Research area

The area included in the research in this paper is the area of the strzeliński County.

Strzelin County is located in the eastern part of the Lower Silesia Voivodeship, at the border with the Opolskie Voivodeship. It has 45 thousand inhabitants (as of 2017) and covers 622 km$^2$ of the area [12]. It is located on the border of two geographical lands: Silesian Lowland and Sudeten Foreland. The northern part of the county, due to its location, topography and high productivity of soils, is used for agriculture, and the southern part of the county includes the Niemczański-Strzeliński Hills with their highest peak Gromnik (393 m asl) [13].

The administrative district was divided into five municipalities (Fig. 1), two of which are urban-rural (Strzelin and Wiązów) and three are rural (Borów, Kondratowice and Przeworno). The table below (Tab. 2) presents the general characteristics of these municipalities.

The municipalities located in the northern part of the county area are situated on the Wroclaw Plain, and those in the south are located on the Niemczański-Strzeliński Hills. Over 80 % of
Table 1. The most important studies on spatial data harmonisation.

| Source | Authors | Area of interest | Main aim | Field | The concept of harmonisation |
|--------|---------|-----------------|----------|-------|------------------------------|
| [3]    | Hakimpour, Yuan, Gepperl | Geodata | Discussion of problems related to integration and coherence of spatial data. | Geography | Data harmonisation is understood as consistent data which, despite many sources, ways of obtaining, taking measurements, processing tools, are uniform, do not differ from each other in quality and quantity. Thanks to harmonisation, resources are saved and at the same time it is possible to analyze data quickly, without the need to verify and check them. |
| [4]    | Sikorska-Mayakowska, Oksewski | Geoenvironmental data | Indicate the existence of problems in reading maps with similar themes for space management, which differ in conceptual models and definitions of the same named objects. | Geodesy and cartography | Harmonization based on modification of conceptual models, their unification in such a way that both maps are readable for the user and do not mislead him, e.g. by duplicating the same names that mean completely different on each map. |
| [5]    | Villa, Molina, Gomarasca, Roccagagliata | European Spatial Data Infrastructure, project HUMBOLDT | Creation and implementation of a framework for the harmonisation of data and geoinformation services related to the INSPIRE Directive. | Geodata | Harmonisation means coherence of tools, services and data. Focusing on cross-border data and increasing data availability for analysis. |
| [6]    | Kuczyńska | MDA and SOA data harmonisation strategies and their application in application schemas | Presentation of how to harmonize data based on MDA and SOA strategies. | Geodesy and cartography | Harmonization as a tool to harmonize application schemas, which are the basis for building spatial databases in geodesy. |
| [7]    | Ewertowski, Ewertowski, Rezczewski, Tomczuk | study of conditions and directions of spatial management | Methods of harmonisation and integration of spatial planning data. | Spatial planning | Harmonisation as a unification of study of conditions and directions of spatial management attributes for different municipalities, so that they become understandable and readable regardless of the municipality that performed them. |
| [8]    | Gotlib, Iwaniak, Oksewski | Reference data for cartography | Indication of tasks to be performed in order to create a coherent reference database based on integrated VMap and TBD data. | Geodesy and cartography | Harmonization in order to ensure consistency of conceptual models - unification of object classification and data visualization models. |
| [9]    | Bac-Bronowicz, Głazewski, Liberadzki, Wilczyńska | Databases BDOT10k and BDOT500 | Analysis of relations between conceptual models of BDOT10k and BDOT500 databases. | Geodesy and cartography | Harmonization understood as modifications to the structure of databases so that both databases are more consistent and data exchange between them is more efficient. |
| [10]   | Szczepaniak-Koltun, Oberski | Zoological and hydrographic maps | Combining the zoological and hydrographic map, introducing a new division of phenomena and objects presented on the maps. | Cartography | The harmonization of the two maps is based on merging them so that they can be complementary to each other, thus creating one map. Such a map is more accessible for analysis. |
| [11]   | Kroczak, Bryndal, Biša, Pylypóbyč, Andreychuk, Rutar | Cross-border data | Analysis of cross-border data resources for the analysis of the War catchment area on the Polish-Ukrainian border. Proposals for data consistency. | Geography | Lack of coherence in the context of incomparable data on rivers, lack of their uniformity - some data are missing, others do not contain the same amount of information. |
Figure 1. Administrative division of the district of Strzelin.

Table 2. Summary of basic information on municipalities in the district of Strzelin (state as of 2017) [13].

| Municipality     | Borów | Kondratowice | Przeworno | Strzelin | Wiązów | All  |
|------------------|-------|--------------|-----------|----------|--------|------|
| Area [km²]       | 99    | 98           | 112       | 171      | 142    | 622  |
| Population [thou.]| 5,3   | 4,5          | 5,0       | 22,0     | 7,5    | 44,3 |
| Agricultural area [%] | 87    | 84           | 74        | 80       | 87     | 82   |

the municipalities occupy areas designated for agricultural crops. This is due to the presence of very good quality soils. The centre of the county is Strzelin, where the county and commune authorities are located. It is also an educational and service centre. The town is also famous for the exploitation of granite and for one of the largest and deepest quarries in Europe [13].

Apart from agriculture, the greatest wealth of the district of Strzelin is stone. In a small area there is a great variety: from granite through quartzite slates, basalt, crystalline limestone, kaolinite, graphite to marble. The northern part of the county area is made up of loess and quaternary formations, thanks to which agriculture develops, and in the south there is a fragment of the Pre-Sudetic block. The Strzelin Hills are built of granite, which is squeezed between quartzites and limestone [14].

In the county there is the deepest quarry in Europe, which reaches a depth of 120 m (Fig. 2). It is 650 m long and 300 m wide. It is located in the county town of Strzelin, right next to the city centre. Granite has been used there for almost a thousand years, and the first official mentions appear in the records in 1233. At present, the quarry is a private property, however, due to its great cultural and traditional mining importance it has been partially made available...
Figure 2. The deepest quarry in Europe - Strzelin [15].

to tourists. Apart from this excavation, several dozen other smaller quarries can be found in the county [14].

4. Materials and methods

4.1. Materials

In order to make a soil-geological map and then find natural conflicts, a soil-agricultural map and a geological map were necessary. The data including the course of isohips, division into map sheets and administrative division were also used.

The soil-agricultural map used in the research was vectorized by Dr Adam Górecki on the basis of scans of soil-agricultural maps in the scale 1:5 000 calibrated on a topographic map in the scale 1:10 000. It was attempted to use a generalized soil-agricultural map created during engineering thesis, which was created using the automated "centroid" method. This map is a soil-agricultural map enriched with data from the Land and Building Register (EGiB), which was obtained from the District Surveying and Cartographic Documentation Centre (PODGiK) in Strzelin. They included information on parcel numbers, their use (designation of land use type - OFU) and discount classes (designation of land use class - OZU and land use type - OZK). However, as it turned out during the works, this map had slight errors which excluded it from further works on the construction of the soil-geological map.

The geological map was vectorized on the basis of scans of geological maps in scales 1:25 000 and 1:50 000, depending on the sheet. The following sheets of maps were obtained from the Polish Geological Institute (PGI): Ciepłowody, Domaniów, Grodków, Jegłowa, Jordanów Śląski, Kondratowice, Kuropatnik, Niemcza, Oława, Strzelin, Szklary, Wiązów, Ziębice. The scans were georeferenced on topographic maps in the scale 1:10 000 and then the boundaries of geological exclusions were vectorised. It was also necessary to describe the digitised fields based on the map legend. The entered data included the map sheet, the division code, division name and stratigraphy. In order to make the geological map more detailed, it was decided to verify the location of river sediments in relation to the course of river courses and the terrain on the basis of the existing contours. This made it possible to determine the need to edit the boundaries of
river sediments in places of river valleys and on hillsides. Figure 3 presents a sample edition.

Figure 3. Comparison of sediments before (coloured fillings) and after editing (red outlines) (own analysis based on PGI data).

Additionally, we used vector data covering the boundaries of administrative units, frames of topographic maps in the PUWG 1992 system and contours. Boundary data of administrative units were collected from the Central Office of Geodesy and Cartography (GUGiK) [16] in shp format. Frames for maps were obtained from the Voivodeship Surveying and Cartographic Documentation Centre (WODGiK). The contour lines were digitised by Dr Adam Górecki on the basis of topographic maps in the scale 1:10 000 in the PUWG 1965 system, which were also presented on topographic maps in the PUWG 1992 system.

4.2. Methods
The applied method is the author’s method, which was based on combining and analyzing two maps - soil-agricultural and geological. Thanks to the combination, a full set of attributes was obtained, which gives the possibility of data analysis.

The first stage of soil-geological map creation was the verification aggregation of soil-agricultural map and geological map data. Its aim was to verify that there are no fields with the same descriptions next to each other and to combine them into one. This procedure was performed with the Dissolve tool in ArcGIS software. It enables efficient indication of areas with the same attributes and at the same time connects neighbouring polygons with the same values. The merging can be done according to any selected layer attributes, and an additional option is the global merging of all the polygons with the same set of attributes into one record in the table - this is Create Multipart. In this case it has not been decided to merge the polygons into common records. Below in Fig. 4 is presented the principle of the Dissolve tool.

The next stage involved combining aggregated soil-agricultural and geological maps using the Union function. Not only the geometry of objects was combined, but also their attributes. Thanks to this, we managed to obtain data on the full set of attributes which are necessary for us.
Then, on the already connected map, the data was "cleaned". The residual polygons generated by using the Union function were deleted. Residual polygons were considered to be very small in size and with an elongated and narrow shape. Their occurrence results from a slight shift of the layers that are joined together. The Eliminate tool was used for this purpose, which connects the residual polygons to adjacent polygons, depending on the option selected, either with the longest common border or with the largest area. A prior selection of the residual training grounds is necessary. In this paper it was decided to determine the maximum area of a residual training ground as $100 \, m^2$. Due to the previously mentioned two possibilities of joining the polygons, at the beginning the polygons were included to their neighbours after their longest common border, and then to those with the largest area. In order to facilitate further data analysis, it was necessary to repeat the Dissolve procedure, this time with the Create Multipart option activated, so as to reduce the number of records as much as possible.

The created soil-geological map contains the following set of attributes:

- soil type and subtype,
- the kind of soil,
- soil species at the first depth level (g1) - from 0 cm to 25 cm below ground level,
- soil species at the second depth level (g2) - from 25 cm to 50 cm below ground level,
- soil species at the third depth level (g3) - from 50 cm to 100 cm below ground level,
- soil species at the fourth depth level (g4) - from 100 cm to 150 cm below the surface,
- soil species at the fifth depth level (g5) - below 150 cm below the ground surface,
- lithological code of the division,
- name of the lithological division,
- stratigraphy (age of rock formation).

An important stage of the work was the comparison of soil-agricultural and geological maps, both graphical and descriptive. Descriptive analysis included attributes in terms of: soil type, subtype, kind and species (at five depth levels), lithology. Thanks to the earlier aggregation of the training grounds, with the same descriptions, into one record, it was possible to eliminate errors of inaccuracies resulting from the different degree of compliance found for the same lists of descriptions in different locations.

The comparison itself was based on the comparison of the attributes of the soil-agricultural map with the geological map and the degree of compatibility between them. The set of attributes could be compatible, i.e. there was a smooth transition from soil to lithology, or incompatible - then there was a natural conflict.

**Figure 4.** Principle of function *Dissolve.*
Natural conflict is a concept created for this work. It is understood as the lack of compatibility of the transition from soil to lithology in a given area. This definition results from the direct relationship between the bedrock defined on a geological map and the soil defined on a soil-agricultural map that can be formed on that rock. If there is a soil on the map that would not be able to develop on a given rock, we are talking about a natural conflict.

The most time-consuming stage of the work was editing natural conflicts, which were not concentrated in certain areas, but were scattered over the entire county. The conflicts were also not dependent on the types of geological or soil divisions, so each case required an individual approach. The following editorial steps can be listed:

- re-analysis of attributes, in order to eliminate potential unnoticed errors and thus eliminate conflicts,
- analysis of the environment of the conflict area in order to facilitate subsequent decisions,
- decisions which attributes to change - soil or geological, based on the analysis of the environment,
- decisions on which attributes will be changed to the original attributes, based on the relationship between soil and geological structure.

The following methods were used to visualize data on maps:

- chorochromatic - it is used to compare areas with each other, according to the criterion of similarity or difference; using it, only qualitative data are presented and the presented areas do not overlap,
- isoline - based on lines connecting the same size of the phenomenon, it can present both physical (altitude above sea level) and theoretical (population density) values; several groups of isolines can be distinguished.

4.3. Data harmonisation

The data harmonisation in this paper was two-stage. In the first stage, the harmonisation was understood as eliminating the large difference in the data scales so that they could be compared, omitting any errors resulting from the difference in the scales. The second stage included editing of natural conflicts.

The input data for the analysis is based on different scales. Geological maps are made in the scales 1:50,000 and 1:25,000, while soil-agricultural maps are in the scale 1:5,000. In order to bring both maps as close as possible to each other so that they can be well analyzed and any errors resulting from the difference in the scales of these maps were minimized, a number of actions were taken when preparing data for further analysis.

The first stage of harmonisation is map calibration. Both geological and soil-agricultural maps were calibrated on topographic maps in the scale 1:10 000. In the next step it was decided to make the geological map more precise during its vectorization. Editing of this map consisted of introducing changes for some of the divisions in relation to the terrain. This stage was extended in later actions by precise edition of river sediments. Their course was changed in such a way that the sediments were located in the river valleys and not e.g. on their slopes. In this way, it was possible to obtain a considerable degree of precision in the analyzed data, which eliminated the differences between the map scales. The general editorial scale of the maps was adopted as 1:10,000, thus the soil-agricultural map was only visually generalised.

The second level of data harmonization was performed at the stage of editing of natural conflicts, which, according to the definition of harmonization, is supposed to lead to data consistency, which in this case is understood as the mutual compatibility of soil-agricultural and geological maps. It is thus the editing of conflicts on maps, leading to the compatibility between soil and geological attributes.
5. Results
The analysis of map attributes allowed to conclude that only two categories of compatibility - compatibility or lack thereof - are not enough. It was necessary to define the category that is allowed as partial compliance. The list of categories is presented below:

- **full** - the passage through the soils to the lithology is smooth, the soil layers lying on the geological layer were able to develop from them,
- **acceptable** - the transition is not smooth, but acceptable, the soil layers only partially correspond to the parent rock,
- **none** - the occurrence of conflict, soils would not be able to form on the geological layers indicated on the map.

At the beginning, the areas were classified according to these categories. On this basis, 20% of the attributes were classified as full compliance, 50% as conflicts and 30% as acceptable compliance. In the process of analysis, doubts arose about many of the lists which were classified as inconsistent. This results directly from the fact that geological maps include examination of geological structures of the surface layer of soil, from about 2 m deep into the ground, while from soil-agricultural maps information about soils can be read up to a maximum depth of 150 cm with an intermediate zone below 150 cm. The intermediate zone (includes depths from 150 cm to 200 cm), is the zone of uncertainty with the most conflicts of interpretation. Thus, there may be a large gap in the transition from soil data to geological data. Therefore it was decided to re-analyze the data. For this purpose, the part of the data which was qualified as a lack of compatibility of the attributes was analysed again. Thanks to this procedure, the number of conflicts was reduced to 40%.

Below are some examples for the different attribute match groups (Tab. 3).

| Code | Type | Kind | Species | Lithology            | Stratigraphy | Compliance |
|------|------|------|---------|----------------------|--------------|------------|
| a    | B    | in   | gsp gsp sk sk sk          | Amphibolites       | Precambrian - Older Paleozoic | full       |
| dgpQ | D    | in   | gsp gsp gsp pl pl deluvial clays and sands | Quaternary        | full       |
| fgpQp3 | Bw   | in   | gsp gsp gsp z z hydroglacial sands and gravels | Quaternary: Pleistocene: Central Poland Glaciation | full       |
| dQ   | D    | in   | gsp gsp gsp sk sk rock rummies, clayey | Quaternary        | acceptable |
| fgpQp3 | D    | in   | gsp gsp gsp pli pli pli ps hydroglacial sands | Quaternary: Pleistocene: Central Poland Glaciation | acceptable |
| gamma | B    | in   | gsp gsp gsp sz sz granites | Carboniferous        | acceptable |
| dBQ  | D    | in   | pli pli i i rock rummies, clayey | Quaternary        | none       |
| dQ   | L    | e    | li li li li li sk sk deluvial clays | Quaternary        | none       |
| fgpQp3 | Dz   | in   | gsp gsp gsp gsp gsp hydroglacial sands | Quaternary: Pleistocene: Central Poland Glaciation | none       |

In this paper it was decided to edit only the attributes of the geological map, due to greater accuracy of the soil-agricultural map (scale 1:5 000), as well as more data which were used to create the map - the number of soil quarries significantly exceeds the number of geological boreholes made to create maps. Most of the conflicts could have been edited in a rather simple way. It was enough to change the lithological description. This consisted in adding soil species or removing a fragment from the name of the division. Then, e.g. water-glacial sands and gravels on till were changed to water-glacial sands and gravel. There were also conflicts that had to
be completely changed. Names were created on the basis of soil attributes and their relation to geological layers, and the factor shaping the formation of this structure was chosen from the conflict’s neighbourhood.

All types of examples are presented in the table below (Tab. 4).

### Table 4. Sample edited conflicts.

| Type | Kind | Species | Code | Lithology | Stratigraphy |
|------|------|---------|------|-----------|--------------|
| A    | d    | gsp     | gsp  | gsp       | Quaternary: Pleistocene | Central Poland Glaciation |
| A    | d    | gsp     | gsp  | ps        | Paleogene - Neogene: Miocene | Mioocene |
| B    | in   | phi    | phi  | phi       | Quaternary: Pleistocene | Central Poland Glaciation: The Older Glaciation: Maximun Stadial |
| B    | in   | gsp    | gsp  | gsp       | Pliocene: Crystalline rock complex Kamenice - Niemcza |
| L    | in   | pgm    | pgm  | pgm       | Quaternary: Pleistocene: Central Poland Glaciation: The Older Glaciation: Maximun Stadial |
| D    | e    | li     | li   | li        | Quaternary: Pleistocene: Northern Poland Glaciation (Baltic) |

As a result of the research, not only did we obtain lists of edited attributes, but also created maps showing combinations of some attributes from tables. There have also been created maps showing some attributes before and after editing, which will be shown in the following Fig. 5 and Fig. 6.
Figure 5. Soil species in the fifth level below 150 cm depth below ground level on the background of lithology - before editing the natural conflicts.
Figure 6. Soil species in the fifth level below 150 cm depth below ground level on the background of lithology - after editing the natural conflicts.
6. Discussion

Data harmonisation can be understood very widely. The INSPIRE Directive [1], which became the basis for the Spatial Information Infrastructure Act [2], namely the harmonisation of data in Poland, focuses on harmonisation based on data systematics, their correct classification, execution, description, metadata as well as spatial and geometric integrity. Very rarely attention is paid to a slightly different kind of data consistency, which is presented in this paper.

Most often harmonisation is understood as a tool for creating coherent conceptual [4] models [8] [9], coherent application schemas [6], unification of attributes [7], data fusion and possibilities of their integration and exchange between databases [8] [9] [10], “equalization” of cross-border data, that is, making it possible to analyze very similar quantitative and qualitative data on both sides of the border [11]. Harmonization is primarily the consistency of data from multiple sources, obtained in different ways, but at the same time without any outliers [3]. It is also a set of tools and services that allow the analysis and processing of these data [5].

Very rarely the authors of the papers draw attention to data that should have something to do with each other in theory, and in fact it turns out that there are places where this coherence is lacking. The evidence for this is the study of the relationship between the geological map and the soil-agricultural map. It is necessary to think about what this inconsistency results from. Whether it is due to inaccuracy of maps and their execution, to high generalization, too small number of measurement points, too extended interpretation of what is underground or maybe from some other factors. Thanks to such harmonization, elements, which are naturally connected in nature, could give more possibilities for spatial analyses and modelling of various phenomena.

To quote from Gazdzicki, harmonization is “bringing about compatibility, mutual complementarity, and consistent interaction” [17]. So not only harmonization as a change of conceptual models, integration of data that duplicate each other, but also compatibility between objects and thematic phenomena presented on maps. In the case analyzed by us, it is the compatibility between the geological substratum and the soils formed on it.

7. Conclusions

The analysis carried out in this article allowed to indicate the occurrence of a problem with coherence of soil and geological data. Therefore, an attempt was made to indicate natural conflicts and then to edit them so that the analysed data were harmonised.

Comparing the previously prepared data with each other, it turned out that the attributes on maps do not match, although they should. This is due to the following relationship: specific soil types are able to form on strictly defined types of geological exclusions. Only in special cases it is possible for a given soil type to find itself in a place where it was not naturally formed. In the first case, it is mainly loess and loess-like formations and other eolic soils. In the second case, the incompatibility may result from the lack of some of the information in the profile of these structures. This is due to the methodology of measurements on the maps under analysis. Soil maps show everything up to 1.5 m depth under the ground surface with an intermediate zone below 1.5 m, while geological maps show geological structures from about 2 m depth below the ground surface. Thus, in some cases, an information gap may occur, meaning no relation between soil layers and geological layers. In any other case, the incompatibility of soil and geological layers results from generalization of maps and their contents (both localization and attribute). This is where the concept of natural conflict defining this incompatibility appears.

Due to the large scale difference, it can be assumed that comparing these maps will generate large errors, understood as misclassified conflicts. Soil-agricultural maps are much more precise, because they were edited on the registry and discount maps, than geological maps, whose degree of generalization is much higher (they are edited in medium scales). Therefore, an attempt was made to harmonise these data. Nevertheless, there is a probability of errors, but not as big...
as the original errors of the unprocessed map. However, even if these errors appeared on the soil-geological map, they could not all be attributed to the difference in scales.

The previously mentioned percentage breakdown of the data (in section 5) shows how high is the percentage of natural conflicts. Therefore, this phenomenon becomes a very big problem in terms of coherence of soil and geological data. Thanks to the indication of places of occurrence of natural conflicts, it is possible to determine the areas which should be re-examined in the indicated scope. It is also advisable to create guidelines how to proceed in such situation and to make the new delimitation more precise.

The process of identifying natural conflicts and the process of editing them in order to eliminate them is a beginning for further research and analysis. The result will be data that will enable the presentation of soils in other selected soil systems, e.g. those run by the FAO (Food and Agriculture Organization), a specialized organization in the UN or in the US system.
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