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Selected issues relating to classification of mountain organic soils in Poland according to the Polish Soil Classification (2011)

Abstract: Despite a large number of organic soil types and subtypes in the Polish Soil Classification the problems of organic soils classification are still very common. In relation to mountain organic soils, in particular. The aim of this paper is to discuss the most common problems related to mountain organic soils classification according to the Polish Soil Classification. Based on authors' own research and literature studies mentioned problem was described. This work allows to define some new proposals, which should be considered during developing of the next update of the Polish Soil Classification (PSC). The most important proposals related to: criteria for organic materials and organic soils, taxonomy position and criteria for shallow organic soils and new definition of mineral material admixture in organic soils.

Key words: organic soils, mountains, Polish Soil Classification, peatlands

INTRODUCTION

Peatlands, thus organic soil occurs in the waterlogged area, where the rate of plant residues accumulation is greater than the rate of decomposition (PSC 2011). In Poland peatlands cover about 12 500 km^2 (Okruszko 1996), including mountain regions (Sudetes and Carpathians), where they cover 890 km^2 (Dembek et al. 2000). The small footprint of mires in upland areas is the result of specific geological and landform conditions (Łajczak 2013), which are usually not conducive to peat accumulation. Rudawy Janowickie (Bogacz et al. 2016), Karkonosze Mts (Bogacz 2005), Izera Mountains (Glina and Bogacz 2013), Stołowe Mountains (Bogacz and Roszkowicz 2010, Glina et al. 2017, Glina et al. 2016a, 2016b), Bystrzyckie Mountains (Bogacz 2005), Bialskie Mountains (Bogacz et al. 2008), Podhale and Tatra Mountains (Łajczak 2001, 2013; Malawska et al. 2006), western Bieszczady (Drewnik et al. 2015; Stolarczyk and Drewnik 2015), Beskids (Margielewski 2006, Margielewski et al. 2011) and Orava-Nowy Targ Basin (Łajczak 2006, 2013) constitute major mountain locations of peatlands. A clear dominance of raised bogs over fen peatlands is observed in Polish mountain ranges. Moreover, due to varied landforms, climatic factors and increasing human impact since the late Holocene (Glina et al. 2017) mountain peatlands are characterized by multiple forms. These facts result in large variability of organic soils morphology. In the PSC (2011) organic soils have been divided into 6 main types and 24 subtypes, as follows: Fibric peat soils (in Polish: gleby torfowe fibrowe), Hemic peat soils (in Polish: gleby torfowe hemowe), Sapric peat soils (in Polish: gleby torfowe saprowe), Folisols (in Polish: gleby organiczne ściółkowe), Limnic soils (in Polish: gleby organiczne limnowe) and Murshic soils (in Polish: gleby organiczne murszowe) (Świtoniak et al. 2016). Despite such a large number of organic soil subtypes, classification is still problematic, in mountain regions in particular (Glina et al. 2016a, 2016b). As it was reported by Kabała (2014), knowledge about soil diversity is growing rapidly and with it rising expectations of the classification system, as well. That is why classification system should be revised and updated in regular intervals.

The aim of this paper is to discuss the most common problems in mountain organic soils classification according to PSC (2011). Based on authors' own research and literature studies, mentioned problem was described in relation to criteria for organic materials, shallow organic soils taxonomy position and occurrence of mineral interlayers in organic soils profiles. This work allow to define some new proposals, which should be considered during developing of the next update of the Polish Soil Classification.

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CRITERIA FOR ORGANIC MATERIALS

According to PSC (2011) organic soils consist of organic material (Histic horizon), which has at least 12% of organic carbon (20% of organic matter) and minimum thickness of 40 cm or 10 cm if overlying lithic rock or rock fragments. Histic horizons consist of peat (fibric, hemic, sapric), mursh, mud, gyttja, litter or mixed organic materials (PSC 2011). In the latest version of PSC (2011) the minimum thickness of Histic horizon has been changed from 30 cm to 40 cm, when comparing to the previous version (PSC 1989). This followed the former edition of USDA Soil Taxonomy (Soil Survey Stuff 2010) and international classification WRB (2006). Consequently, in many peatland areas in the Sudetes, as well in the Carpathians, a significant decrease in the total area of organic soils was observed. In mountain areas of Poland shallow organic soils with organic layer slightly exceed 40 cm or even 30 cm are very common (Table 1), so that is why such requirements are not suitable for Polish conditions. Moreover, the „Polish tradition" of peat science (e.g., Okruszko 1976, 1993, 1996), opts for re-adoption of the required 30 cm thickness for organic materials. In this system numerous studies were done, including cartographical and geological documentations of peatlands. Furthermore, the merely Polish concept of the stages of mursh forming process (MtI, MtII, MtIII), defined by Okruszko (1993) was also based on top 30 cm thick layer of organic material. That is why PSC (2011) in the case of mursh soils do not meet criteria for the above mentioned classification. The problem of distinguishing and classifying mursh material is topic for the next research article, in this point authors want only to note this issue. If the next update of PSC the minimum thickness of organic material would be changed on 30 cm, thus control profile (in Polish: profil kontrolny) for organic soils also should be changed. The authors propose to use following divisions: top part (in Polish: piętro wierzchnie) – 0–30 cm, middle part (in Polish: piętro środkowe) – 30–100 cm and bottom part (in Polish: piętro dolne) – 100–130 cm. Another essential issue is the actual criterion for the minimum carbon content for the organic materials. In the authors' opinion actual threshold for total organic carbon content, defined as 12% is proper. In Polish conditions fibric and hemic peat have even greater amount of organic carbon, often above 20–30% (e.g. Bogacz 2010, Bogacz et al. 2012, Drewnik et al. 2015, Glina et al. 2016c), whereas in sapric peat or mursh material the content of carbon slightly exceed 12% in some cases (e.g. Bogacz 2010, Bogacz and Roszkowicz 2010, Glina et al. 2016b). Ideas to accept the lowest limit of carbon content as 20%, as it is in the WRB (2015) seem to be misplaced for Polish conditions, especially for organic soils in the mountain areas.

SHALLOW ORGANIC SOILS DEFINITION AND CLASSIFICATION CRITERIA

Shallow peat deposits could be the result of natural unfavorable sedentation conditions (McGuire et al. 2009) or human impact in the last centuries (Glina et

TABLE 1. Shallow organic soils in the Polish mountain zone (some examples)

No.	Thickness of organic layer (cm)	Peat material	Region		Reference
1	85	fibric	eastern Sudetes	Bialskie Mountains	Bogacz et al. 2008
2	75	fibric-hemic	eastern Sudetes	Bialskie Mountains	Bogacz et al. 2008
3	50	fibric	eastern Carpathians	western Bieszczady Mountains	Drewnik et al. 2015
4	45	hemic-fibric	eastern Carpathians	western Bieszczady Mountains	Drewnik et al. 2015
5	30	hemic-sapric	central Sudetes	Stołowe Mountains	Bogacz and Rutkowska 2010
6	50	fibric-sapric	central Sudetes	Stołowe Mountains	Bogacz and Rutkowska 2010
7	35	fibric-hemic	western Sudetes	Izerskie Mountains	Glina and Bogacz 2013
8	46	hemic	western Sudetes	Izerskie Mountains	Glina and Bogacz 2013
9	60	sapric-fibric	western Sudetes	Rudawy Janowickie	Bogacz et al. 2016
10	36	hemic-sapric	central Sudetes	Stołowe Mountains	Glina et al. 2016a
11	80	hemic-sapric	western Sudetes	Rudawy Janowickie	Bogacz et al. 2016
12	64	hemic-sapric	central Sudetes	Stołowe Mountains	Glina et al. 2016b
13	49	sapric	central Sudetes	Stołowe Mountains	Glina et al. 2016c
14	65	hemic-fibric	central Carpathians	Orava-Nowy Targ Basin	Łajczak 2006
15	80	fibric	central Carpathians	western Tatra Mountains	Malawska et al. 2006

al. 2017). Long-term drainage of peatlands can be linked to intensive mineralisation and subsidence of peat which results in reduction of organic material thickness (Glina et al. 2016c). Described shallow organic soils have been omitted in the latest PSC (2011). In the guidelines for organic soil classification (PSC 2011) it is clearly stated that classification should be based on the dominant soil material in the central part „piętro środkowe" (40–100 cm), while in shallow peat soils the organic layer thickness in many cases slightly exceed 40 cm (Table 1). Such examples comes from both, Sudetes (e.g. Bogacz and Rutkowska 2010, Glina and Bogacz 2013, Glina et al. 2016b) and Carpathian mountains (e.g. Drewnik et al. 2015). The most sensible approach would be to determine the subtype of shallow organic soils based on the dominant type of peat material (sapric, hemic, fibric) in the whole profile, which was also postulated by Glina et al. (2016a). It will be an exception only for shallow organic soils. Well-developed organic soils with full "control profile" should be classified as it is state in PSC (2011). The next issue that requires detailed discussion is the maximum depth of shallow organic soils. Clearly defined minimum thickness (40 cm or 30 cm as it was discussed in the previous subchapter) should be supplemented with the maximum thickness (authors' proposal is 80 cm). Another serious omission in the PSC (2011) is the lack of shallow fibric peat soil subtype within the type of fibric peat soils, while these soils were found in many regions of Polish mountains (e.g. Malawska et al. 2006, Bogacz et al. 2008, Drewnik et al. 2015) (Table 1). Following this, a new subtype, namely: shallow fibric peat soils (in Polish: gleby torfowe fibrowe płytkie), should be implemented to the classification. This taxonomy unit could include shallow organic soils (organic material thickness ≥30 cm and ≤80 cm) mainly consist of fibric peat material (>40% of rubbed fiber) and lying directly on mineral bedrock. This proposal should also be considered during developing of the next update of Classification of Polish Soils.

Mineral interlayers in organic soils

The presence of mineral admixtures or continuous layers within organic soil profiles is another issue for discussion. Their occurrence in organic soils might lead to periodically inhibition of peat accumulation process and increase of trophy status (Bogacz 2005). In the PSC (2011) only the fluvic (river, marine or lake sediments) materials are listed in the context of organic soils. Moreover, the presence of these layers, only in the (40–100 cm) and bottom (100–130) layer of soil, is taken into consideration. However, numerous papers report that mineral interlayers not only consist of fluvial sediments but also occur as a result of slope processes. They can also be present in the uppermost (0–40 cm) soil layer (Table 2). The genesis of these materials in mountain peatlands should be considered more broadly. We observed mineral layers in organic soils, which are the result of gravitational displacements e.g. in the areas of slope peatlands in central Sudetes (Glina et al. 2016b) and landslide peat bogs in Carpathians (Margielewski et al. 2011). A peculiar example was described by Majewski (2016) in peat soils from transition bog in central Sudetes. The author recorded thick mineral (sand) interlayers between peat materials (Table 2). Described peatland was periodically covered by sand from weathered sandstone outcrops surrounding this area. The mentioned examples demonstrate the need to expand the definition of mineral material which create layers or admixtures in organic

TABLE 2. Organic soils with mineral interlayers in the Polish mountain zone

No.	Soil thickness (cm)	Peat material	Depth of mineral layers	Type of mineral material	Region		Reference
1	115	fibric	5-21, 40-45	sand	central Sudetes	Stołowe Mountains	Majewski 2016
2	84	hemic-sapric	27-46, 57-61	sand	central Sudetes	Stołowe Mountains	Majewski 2016
3	42	sapric	7-14	loamy sand	central Sudetes	Stołowe Mountains	Glina et al. 2013
4	50	fibric	14-23	sand	central Sudetes	Stołowe Mountains	Glina et al. 2016b
5	50	sapric	17-22, 29-33	sand	central Sudetes	Stołowe Mountains	Bogacz and Rutkowska 2010
6	80	hemic-sapric	6-16, 24-33	sand	central Sudetes	Stołowe Mountains	Bogacz and Roszkowicz 2010
7	200	sapric-hemic	22-32, 72-80	loamy sand	Outher Carpathians	Beskid Sądecki Mountains	Margielewski et al. 2011
8	300	sapric	38-50, 95-100, 112-120	loamy sand	Outher Carpathians	Beskid Wyspowy Mountains	Margielewski 2006

soils. Moreover, a new soil subtype, namely: Muddy-fibric peat soils (in Polish: gleby torfowe fibrowe zamulone) within the type of Fibric peat soils (in Polish: gleby torfowe fibrowe) should be added. Currently in the PSC (2011) only Muddy-hemic (in Polish: gleby torfowe hemowe zamulone) and Muddy-sapric peat soils (in Polish: gleby torfowe saprowe zamulone) are listed. However, as it is reported in Table 2, fibric peat soils with mineral layers also occur in Polish mountains. According to the PSC (2011), organic soil horizons with admixture of mineral material should be marked as O/C, while the C symbol is already used for continuous mineral layers within or underlying organic soils. We suggest to add the symbol "+" if the approximate admixture of mineral material is lower than 50% volume of the whole organic horizons e.g. Oa+ – sapric peat with mineral admixtures. More detailed description of the mineral admixtures is proposed to be used in the guidelines for soil description (in Polish: Przewodnik terenowy do opisu gleb) designed by Polish Soil Science Society, which hopefully will be accepted and officially published soon. It is stated in this guidelines that the organic horizon "O" enriched in mineral particles should be additionally characterized by addition of "t + p" (peat + sand, in Polish: torf + piasek), "t + g" (peat + loam, in Polish: torf + glina), t + i (peat + clay, in Polish: torf + ił) or "t + py" (peat + silt, in Polish: torf + pył). This is proper approach, but there is no need to repeat these symbols in the next update of the Polish Soil Classification. On the taxonomy level it should only by marked by "+" symbol, which indicates that it is mineral admixture in organic horizon. Furthermore, it can be described in detail on the morphology level as it is defined in the proposed guidelines.

FINAL REMARKS

This paper shows the most common problems of classification and morphology description of mountain organic soils. The examples from Polish Sudetes and Carpathians allowed to define some general conclusions which should be considered during developing of the next Polish Soils Classification update.

1. It is proposed to define two most important criteria for organic materials: organic carbon content and organic material thickness, as follow: 12% and 30 cm. Due to these changes, new division of control profile (in Polish: profil kontrolny) for organic soils should be adopted.
2. New subtypes: Shallow-fibric peat soils (in Polish: gleby torfowe fibrowe płytkie) and Muddy-fibric peat soils (in Polish: gleby torfowe fibrowe zamulone) within the type of Fibric peat soils (in Polish: gleby torfowe fibrowe) should be implement to the classification.
3. It is proposed to expand the definition of mineral material which occur in organic soils as admixtures or constitute continuous layers. Moreover, it should be clearly stated that mineral layers may also be present in the uppermost part (0–40 cm) of organic soils.
4. If the approximate admixture of mineral material is lower than 50% of the whole volume of organic horizons, it is suggested to add the symbol "+" to the list of additional symbols used in soil description.

REFERENCES

Bogacz A., 2005. Właściwości i stan przeobrażenia wybranych gleb organicznych Sudetów. Zeszyty Naukowe Akademii Rolniczej we Wrocławiu, Rozprawy nr 507, Wrocław: 145 ss. (in Polish with English abstract).

Bogacz A., Ochej A., Niemirowska I., 2008. Organic soils properties in selected areas in Bialskie Mountains. Roczniki Gleboznawcze – Soil Science Annual 59(3/4): 31–40 (in Polish with English abtract).

Bogacz A., Roszkowicz M., 2010. The influence of forest on the changes of organic soils properties in the marginal part of the Krągłe Mokradło peatland (Stołowe Mountain National Park). Roczniki Gleboznawcze – Soil Science Annual 61(2): 15–20 (in Polish with English abstract).

Bogacz A., Rutkowska H., 2010. Organic soils in the valley areas of the Stołowe Mountain National Park. Roczniki Gleboznawcze – Soil Science Annual 61(4): 15–25 (in Polish with English abstract).

Bogacz A., Dzięcioł D., Glina B., Gersztyn L., 2012. Peat soils in the restoration Niknąca Łąka peatland in the Stołowe Mountains National Park. Roczniki Gleboznawcze – Soil Science Annual 63(2): 3–8.

Bogacz A., Andrzejczak M., Tomaszewska K., Podlaska M., 2016. Plant communities, properties, and age of organic soils in the post-extraction sites of the Trzcińskie Mokradła Peatland (Sudetes Mts., SW Poland). Soil Science Annual 67(2): 79–87.

Dembek W., Piórkowski H., Rycharski M., 2000. Mokradła na tle regionalizacji fizyczno-geograficznej Polski. Wyd. IMUZ, Falenty: 136 ss. (in Polish).

Drewnik M., Walas J., Stolarczyk M., 2015. General description and soils properties of hanging peat bog on the north-eastern slope of Mt Szeroki Wierch (Western Bieszczady Mts). Roczniki Bieszczadzkie 23: 319–333 (in Polish with English abstract).

Glina B., Bogacz A., 2013. Concentration and pools of trace elements in the organic soils in the Izera Mountains. Journal of Elementology 18(2): 199–208.

Glina B., Bogacz A., Bojko O., Kordyjarek M., 2013. Diversity of soils in the peatland located on slope near Karłów (Stołowe Mountains National Park). EPISTEME 18(3): 287–296.

Glina B., Malkiewicz M., Mendyk Ł., Bogacz A., Woźniczka P., 2017. Human affected disturbances in vegetation cover and peatland development in the late Holocene recorded in shallow

mountain peatlands (Central Sudetes, SW Poland). Boreas, DOI 10.1111/bor.12203

Glina B., Bogacz A., Woźniczka P., 2016a. Nitrogen mineralization in forestry-drained peatland soils in the Stołowe Mountains National Park (Central Sudetes Mts). Soil Science Annual 67(2): 64–72.

Glina B., Bogacz A., Pikus H., Pawluczuk J., 2016b. Anthropopressure and weather conditions impact on mineral nitrogen content in organic soils from fen peatlands in the Stołowe Mountains. Polish Journal of Soil Science 49(1): 1–13.

Glina B., Bogacz A., Gulyas M., Zawieja B., Gajewski P., Kaczmarek Z., 2016c. The effect of long-term forestry drainage on the current state of peatland soils: A case study from the Central Sudetes, SW Poland. Mires and Peat 18(21): 1–11.

IUSS Working Group WRB, 2006. World Reference Base for Soil Resources, A framework for international classification, correlation and communication. World Soil Resources Report No. 103. FAO, Rome: 143 pp.

IUSS Working Group WRB, 2015. World Reference Base for Soil Resources 2014, update 2015 International soil classification system for naming soils and creating legends for soil maps. World Soil Resources Report No. 106. FAO, Rome: 232 pp.

Kabała C., 2014. Classification of Polish Soils – current state and further development. Soil Science Annual 65(2): 91–98.

Łajczak A., 2001. Waloryzacja geomorfologiczno-hydrologiczna torfowisk Orawsko-Podhalańskich i propozycja poprawy ich nawodnienia. Problemy Zagospodarowania Ziem Górskich 47: 75–91 (in Polish).

Łajczak A., 2006. Torfowiska Kotliny Orawsko-Nowotarskiej – rozwój, antropogeniczna degradacja, renaturyzacja i wybrane problemy ochrony. PAN, Kraków: 147 ss. (in Polish).

Łajczak A., 2013. Role of land relief and structure in the formation of peat bogs in mountain areas, as exemplified by the Polish Carpathians. Landform Analysis 22: 61–73.

Majewski W., 2016. Influence of mineral interlayers on physical and physicochemical properties of the organic soils from peatland located in the Białe Skały area (Stołowe Mountains). Master thesis. Poznań University of Life Sciences: 59 pp. (in Polish with English abstract).

Malawska M., Ekonomiuk A., Wiłkomirski B., 2006. Polycyclic aromatic hydrocarbons in peat cores from southern Poland: distribution in stratigraphic profiles as an indicator of PAH sources. Mires and Peat 1(5): 1–14.

Margielewski W., 2006. Records of the Late Glacial – Holocene palaeoenvironmental changes in landslide forms and deposits of the Beskid Makowski and Beskid Wyspowy Mts. area (Polish Outer Carpathians). Folia Quaternaria 76: 1–149.

Margielewski W., Michczyński A., Kołaczek P., Obidowicz A., Pazdur A., 2011. Record of the meso-and neoholocene palaeoenvironmental changes in the Jesionowa landslide peat bog (Beskid Sądecki Mts. Polish Outer Carpathians). Geochronometria 38(2): 138–154.

McGuire A.D., Anderson L.G., Christensen T.R., Dallimore S., Guo L., Hayes D. J., Heimann M., Lorenson T. D., Macdonald R.W., Roulet N., 2009. Sensitivity of the carbon cycle in the Arctic to climate change. Ecological Monographs 79: 523–555.

Okruszko H., 1976. Zasady rozpoznawania i podziału gleb hydrogenicznych z punktu widzenia potrzeb melioracji. Biblioteczka Wiadomości IMUZ 52: 7–54 (in Polish).

Okruszko H., 1993. Transformation of fen-peat soil under the impact of draining. Zeszyty Problemowe Postępów Nauk Rolniczych 406: 3–73 (in Polish).

Okruszko H., 1996. Characterization and valuation of wetlands and grasslands in Poland in the aspect of natural environment protection. Materiały Seminaryjne IMUZ, Falenty 35: 139 pp. (in Polish with English abstract).

Polish Soil Classification (Systematyka Gleb Polski), 1989. Roczniki Gleboznawcze – Soil Science Annual 40 (3/4): 1–150 (in Polish).

Polish Soil Classification (Systematyka Gleb Polski), 2011. Roczniki Gleboznawcze – Soil Science Annual 62(3): 1–193 (in Polish).

Soil Survey Staff, 2010. Keys to Soil Taxonomy, 11th ed. USDA-Natural Resources Conservation Service, Washington D.C: 346 pp.

Stolarczyk M., Drewnik M., 2015. Morphology and selected properties of peat bog soils located in the Syhłowaciec valley near Wołosate village (Bieszczady National Park). Roczniki Bieszczadzkie 23: 335–347 (in Polish with English abstract).

Świtoniak M., Kabała C., Charzyński P., 2016. Proposal of English equivalents for the soil taxa names in the Polish Soil Classification. Soil Science Annual 67(3): 103–116 (in Polish with English abstract).

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Wybrane problemy klasyfikacji gleb organicznych obszarów górskich w odniesieniu do Systematyki Gleb Polski (2011)

Streszczenie: Pomimo dużej liczby typów i podtypów wyróżnionych w obrębie rzędu gleb organicznych w aktualnej Systematyce Gleb Polski, problem klasyfikacji utworów organicznych jest nadal często spotykany. Dotyczy to zwłaszcza gleb organicznych obszarów górskich. Głównym celem niniejszego opracowania jest dyskusja nad problemem klasyfikacji gleb organicznych obszarów górskich według aktualnie obowiązującej Systematyki Gleb Polski. W oparciu o badania własne prowadzone na obszarze Sudetów oraz analizie dostępnej literatury dotyczącej gleb organicznych z obszaru Karpat, przedstawiono propozycje, które powinny być uwzględnione w trakcie prac nad nowym wydaniem Systematyki Gleb Polski. Propozycje dotyczą kryteriów wydzielania materiałów i gleb organicznych, pozycji taksonomicznej płytkich gleb organicznych oraz obecności i definicji mineralnych przewarstwień w obrębie profilu gleby organicznej.

Słowa kluczowe: gleby organiczne, góry, Systematyka Gleb Polski, torfowiska