# Phytocenoses of dolomite quarries in the neighbourhood of the Ruba town, Belarus

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**Abstract.** This paper explores the structure of phytocenoses covering the slopes of dolomite quarries located in the vicinity of Ruba, Vitebsky District, Belarus. Operated for a rather long period and abandoned at different times, the quarries in question have become home to plant communities in various stages of recovery. Descriptions of these communities have been fed into datasets outlining the key patterns of primary and then secondary succession. These findings are of practical as much as of theoretical value.

## 1 Introduction

In common with the production of any other fossil fuels, dolomite mining can have both positive and negative ramifications. Inevitably, regional economic growth goes hand in hand with adverse outcomes, which affect local ecosystems at the least [1, 2, 3]. In general, the study of succession in technogenic landscapes is a relevant area. [4, 5, 6, 7, 8]. Dolomite extraction inflicts certain damage on the environment as well. The dolomite field examined in this paper is located in the neighbourhood of the town of Ruba, Vitebsky District, Belarus. It has been mined since 1931. The open-pit technology applied there is fraught with critical implications for the natural landscape — changes in the quarry area itself and around the waste dumps. It disturbs the site's hydrological regime, leading to a substitution of natural plant communities with anthropogenic ones. Once the fields are depleted, recovery of the quarries and waste dumps comes to the fore. There are three quarries of this kind around Ruba. Another one, Gralyovo, is still active. The disused ones are undergoing natural colonisation by herbs, shrubs and trees, which can be viewed as primary succession. However, the topic of studying the primary succession of dolomite quarries has hardly been touched upon [9].

We aim at identifying the differences in the structures of the phytocenoses growing on the slopes of the dolomite quarries of various ages around Ruba in various stages of succession.

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## 2 Equations and mathematics

Our study covered the areas of the dolomite quarries formerly operated by Dolomit OJSC in the neighbourhood of Ruba, where mining operations ceased at different times, as suggested by marked differences in the communities growing along their slopes.

The quarries studied in this paper are Tyakovo-Koytovo, Ruba and Gralyovo. At Tyakovo-Koytovo quarry, mining continued from 1970 to 1978, when it was suspended because of a protected site (Ilya Repin's estate) in its central part. Ruba quarry was worked from 1950 until depleted and disused in 1985. Gralyovo has been in operation since 1973 (Fig. 1).

We did the fieldwork in 2021–2022, from June to September.

We set up transect No. 1 on the southeast-facing slope of Tyakovo-Koytovo, transect No. 2 on the west-facing slope of Ruba and transect No. 3 on the west-facing slope of Gralyovo. The transects were 10 m wide and ran from the upper edge of the overgrown slope down to the water's edge (lower borderline). We described the herb and low shrub layer across 5x5 m sections using a Ramensky grid, identifying the species composition and overall projective cover. We produced a total of 9 descriptions. In order to analyse the soil profile from the transect's upper borderline down to its lower borderline, we dug trenches crosscutting the area stretching from the foot of the slope up to its summit, spacing them 5 m apart. For the tree layer, we determined the height of the trees and the trunk diameter at the base. We used a Suunto altimeter for measuring the height of the forest stand, an increment borer for the age and a tree calliper for the diameter [10]. Plants were identified based on a guide to the flora of Belarus [11] and adjacent areas [12, 13].

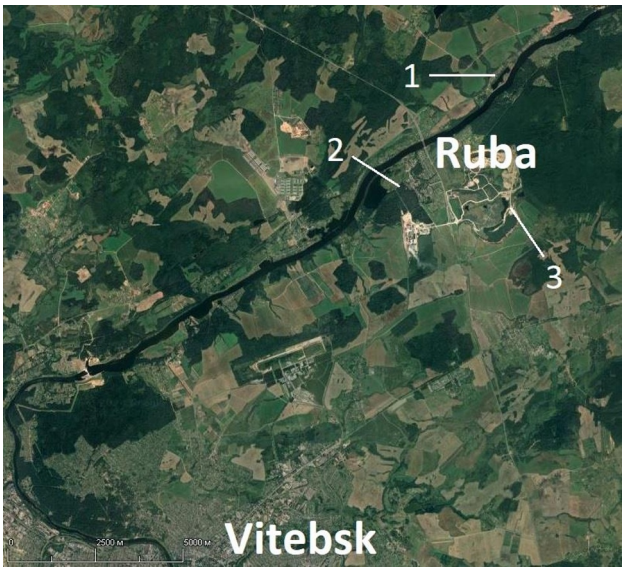


**Fig. 1.** Study location. 1 — Tyakovo-Koytovo; 2 — Ruba; 3 — Gralyovo

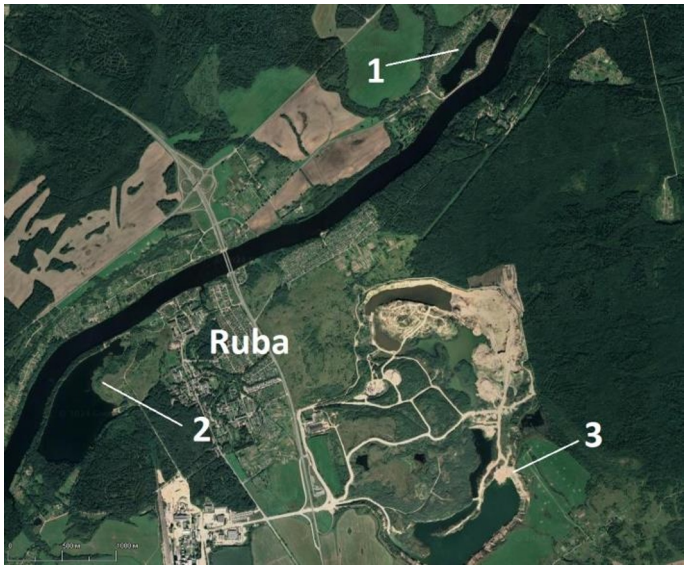


**Fig. 2.** Layout of sample plots. 1 — Tyakovo-Koytovo; 2 — Ruba; 3 — Gralyovo

Basal area was defined as the ratio of the total basal area of the tree layer to a unit of area (most commonly hectares) and estimated using the following formula:

$$P = \frac{\sum_{i=1}^{n}((d_i/2)^2 \times \pi)}{S} \quad (1)$$

where
di — trunk diameters;
S — unit of area.
Density was determined as the ratio of the number of individual plants to a unit of area (most commonly hectares as well) and calculated as follows:

$$N = \frac{n}{S} \quad (2)$$

where
n — number of individual plants;
S — unit of area.
The collected herbarium is stored at the Department of Zoology and Botany at Vitebsk State University Named After P.M. Masherov.

## 3 Results

### 3.1 Species composition of plant communities

The herb and low shrub layer of the forest community growing on the slope of Tyakovo-Koytovo quarry (transect No. 1) is dominated by broad-leaved chervil and common nettle. The projective cover of the former diminishes from 60–70% in the upper part of the slope down to 30–40% in the lower part, while the projective cover of the latter, vice versa, increases from 20–30% to 40–50% respectively (Table 1), which may attest to a definite change in environmental conditions (most likely elevated humidity). We should also mention that such species largely relate to ruderal communities, which may suggest that succession is still underway. It is also noteworthy that, to a greater or lesser extent, all the species

discovered in the herb and low shrub layer are sciophytes and scioheliophytes. Their overrepresentation stems from high crown closure.

**Table 1.** Species composition and projective cover of the herb and low shrub layer in transect No. 1 (Tyakovo-Koytovo)

| No. | Species | Section | | |
|---|---|---|---|---|
| | | No. 1 (upper) | No. 2 (central) | No. 3 (lower) |
| 1. | *Equisetum sylvaticum* L. | – | – | 5% |
| 2. | *Dryopteris filix-mas* (L.) Schott | – | – | + |
| 3. | *Myosotis sparsiflora* Pohl | – | – | + |
| 4. | *Chaerophyllum aromaticum* L. | 60–70% | 60% | 30–40% |
| 5. | *Urtica dioica* L. | 20–30% | 5% | 40–50% |
| 6. | *Anthriscus sylvestris* (L.) Hoffm. | 0–5% | – | |
| 7. | *Rubus idaeus* L. | – | – | + |
| 8. | *Anemone nemorosa* L. | – | 30–40% | – |
| 9. | *Stellaria media* (L.) Vill. | + | – | – |
| 10. | *S. nemorum* L. | – | 0–5% | 10–20% |
| 11. | *Chelidonium majus* L. | – | + | + |
| 12. | Lysimachia nummularia L. | – | + | – |
| 13. | *Geum urbanum* L. | + | – | – |
| 14. | *Agrostis tenuis* Sibth. | + | – | – |
| 15. | *Galium aparine* L. | + | – | – |

The younger meadow community discovered on the slope of Ruba quarry (transect No. 2) almost exclusively features the herb and low shrub layer (Table 2). It is dominated by grasses, namely cock's-foot (30%), meadow foxtail (10%), common reed (10%) and field horsetail (40%). The data obtained qualifies this community as a grass and forb meadow. No moss or lichen layers were found in the transects under study. Several shrubs and low trees in this community could be most logically associated with the understorey. This group is dominated by various species of the genus *Salix* (basically goat willow, eared willow and crack willow), silver birch and *Populus tremula* (aspen). Individual guelder roses and sea buckthorns are also present.

**Table 2.** Species composition and projective cover of the herb and low shrub layer in transect No. 2 (Ruba)

| No. | Species | Section | | |
|---|---|---|---|---|
| | | No. 1 | No. 2 | No. 3 |
| 1. | *Trifolium campestre* Schreb. | + | + | + |
| 2. | *T. pratense* L. | + | + | - |
| 3. | *Potentilla anserina* L. | 5% | + | + |
| 4. | *Ranunculus acris* L. | + | 0–5% | - |
| 5. | *R. repens* L. | - | - | + |
| 6. | *Dactylis glomerata* L. | 30% | 30–40% | 10% |
| 7. | *Bromopsis inermis* (Jeyss) Holub | - | + | - |
| 8. | *Alopecurus pratensis* L. | 10% | 10% | 5% |
| 9. | *Phleum pratense* L. | + | + | - |
| 10. | *Plantago major* L. | + | + | + |
| 11. | *Equisetum arvense* L. | 40% | 40–50% | 30% |
| 12. | *Carex rostrata* Stokes | - | - | 20% |
| 13. | *Phragmites australis* (Cav.) Trin. ex Steud. | - | - | 30% |
| 14. | *Alchemilla vulgaris* L. | + | + | + |

| | | | | |
|---|---|---|---|---|
| 15. | *Taraxacum officinale* (L.) Webb ex F.H.Wigg. | + | - | - |
| 16. | *Artemisia vulgaris* L. | - | + | - |
| 17. | *Elytrigia repens* (L.) Nevski | + | - | - |
| 18. | *Agrostis tenuis* Sibth. | + | + | - |
| 19. | *Festuca pratensis* Huds. | + | + | - |

Species vary considerably across the communities of different age. What is striking, however, is an almost complete absence of ruderal and 'transitory' species, which may be evidence that the analysed stages of secondary succession are steady.

The youngest community — the one of Gralyovo quarry (transect No. 3) — mainly features ruderal species (Table 3). This transect also stands out for the low (compared to the other transects) overall projective cover of the herb and low shrub layer and, therefore, a large percentage of bare soil. Quite naturally, this fact suggests that overgrowing processes started at this quarry rather recently.

**Table 3.** Species composition and projective cover of the herb and low shrub layer in transect No. 3 (Gralyovo)

| No. | Species | Section | | |
|---|---|---|---|---|
| | | No. 1 (upper) | No. 2 (central) | No. 3 (lower) |
| 1. | *Tussilago farfara* L. | 30% | 40% | 50% |
| 2. | *Hippophae rhamnoides* L. | 10% | 10% | 0–5% |
| 3. | *Vicia cracca* L. | – | 0–5% | – |
| 4. | *Trifolium pratense* L. | – | 30% | 10% |
| 5. | *Taraxacum officinale* Wigg. s. l. | – | 0–5% | – |
| 6. | *Atriplex sagittata* Borkh.* | | 50% | 10% |
| 7. | *Conyza canadensis* (L.) Cronq. | – | 0–5% | – |
| 8. | *Typha angustifolia* L. | – | 0–5% | 10% |
| 9. | *Artemisia vulgaris* L. | 10% | 20% | – |
| | *Artemisia campestris* L. | – | 0–5% | – |
| 10. | *Melilotus albus* Medik. | – | 0–5% | – |
| 11. | *Lupinus polyphyllus* Lindl. | – | 0–5% | – |
| 12. | *Solidago canadensis* L. | – | 20% | – |
| 13. | *Calamagrostis epigeios* (L.) Roth | 40% | 20% | 10% |
| 14. | *Lotus corniculatus* L. | – | 0–5% | – |

* Rare for Belarus

## 3.2 Development characteristics of the tree and shrub layers and understorey

Our study revealed the species, sizes and ages of the tree layers at the quarries in question.

As previously stated, the younger meadow community of Ruba (transect No. 2) has no tree layer. Its understorey is represented by different *Salix* species, silver birch and aspen. By sawing the trees, we found out that the oldest ones are about 30 to 35 years of age, which brings us to the conclusion that the surface of the quarry in question was being overgrown (and thus developing this particular phytocenosis) around the late 1980s and early 1990s. The average age of the shrubs and young trees is less than twenty years (the oldest and youngest trees which did not comply with the overall distribution pattern were rejected from the sample). The birch had the average height of 4.5 m and the average trunk diameter of 9 cm; the aspen had the average height of 4 m and the average trunk diameter of 8 cm. Since the sample contained but a few individual trees, we did not calculate the average trunk cross-sectional area or the basal area. The density of various tree and shrub species is specified in the table 4 below.

**Table 4.** Understorey density on the slope of Ruba quarry (transect No. 2), pcs/ha

| Total | *Silver birch* Roth | *Salix* × *fragilis* L. | *Salix caprea* L. | *Salix aurita* L. | *Viburnum opulus* L. | *Hippophae rhamnoides* L. | *Populus tremula* L. |
|---|---|---|---|---|---|---|---|
| 1,180 | 300 | 60 | 460 | | 40 | 20 | 220 |

The forest stand of Tyakovo-Koytovo quarry (transect No. 1) is dominated by the grey alder and bird cherry. The aspen, silver birch and Norway maple can be found in limited quantities. The oak is also present in the understorey. A certain pattern can be traced in how species vary between different parts of the tree layer, with more bird cherries in the upper part of the slope and more grey alders in the lower. Trunk diameters and tree heights are rather erratic and do not depend on the tree's position in the transect. This may suggest that after dolomite mining was discontinued, the entire slope was getting overgrown all over in an erratic manner.

We obtained data about the basal area and density of the forest stand (Table 5).

**Table 5.** Characteristics of the forest stand on the slope of Tyakovo-Koytovo quarry (transect No. 1)

| | Total | *Padus avium* Mill. | *Alnus incana* (L.) Moench | *Populus tremula* L. |
|---|---|---|---|---|
| Average diamater, cm | 19.53 | 17.50 | 19.04 | 29.50 |
| Average height, m | 13.63 | 13.67 | 13.44 | 15.00 |
| Cross-sectional area, $cm^2$ | 1,197.05 | 961.63 | 1,138.02 | 2,732.59 |
| Basal area, $m^2$/ha | 7.51 | 1.53 | 4.61 | 1.37 |
| Density, pcs/ha | 240 | 60 | 160 | 20 |

Table 5 shows that the grey alder, which prevails in this tree layer, outweighs other species by both basal area and density. The least common trees are individual aspens, which have most likely remained from the flora of the previous succession stage.

As the core samples showed, the community of this succession stage has the age of 72±5 years. This result was obtained by evaluating the core samples taken from the largest trees for which sampling was possible. The average age of the tree layer is 57 years (while the quarry itself was put into operation in 1970, 52 years ago, and discontinued in 1978, i.e., 44 years ago).

The transect also features an alder bigger than the other trees (largely by trunk diameter). We were unable to precisely establish the age of the tree due to an age-related core damage (extensive rot). We can claim for sure, however, that it is older than 90–100 years. It is most likely that this tree had already been there before active mining started at the quarry and that it witnessed the transformation of these lifeless areas into a broadleaved forest.

The shrug layer and the understorey are less pronounced (fewer than 10 individuals per transect) and largely feature the grey alder and bird cherry understorey. This is due to the high crown closure of the tree layer and, as a result, lack of light below (as mentioned in part 3.2.). Active growth of recovery plants usually happens when there are natural or artificial openings in the crowns. In this particular case (a relatively young community), however, this is rather rare.

## 4 Conclusion

The species composition and projective cover of the lower layers vary substantially across the three transects. The species composition of transect No. 1 is characteristic of broadleaved forests in the northeast of Belarus (albeit with a limited presence of ruderal species). Transect No. 2 indicates a typical grass and forb community. However, field horsetail is also abundant (up to 40% on average). Transect No. 3 is notable for ruderal species which are capable of getting firmly rooted on the slope of the rather young quarry.

A discernible tree layer can only be observed in transect No. 1 (the oldest quarry). The spatial structure of the tree layer is indicative of species specificity amidst changing environmental conditions: most bird cherries grow near the upper borderline of the transect at the largest distance from the water edge and waterlogged areas; grey alders, on the contrary, grow across the entire slope where moisture is higher. Grey alders prevail by basal area and density and are predominant in the tree layer. The least common species is aspen. Individual aspen trees have most likely remained from the flora of the previous succession stage. As revealed by the core samples, the age of the community in this succession stage is 72±5 years. This result was obtained by assessing the samples from the biggest trees for which sampling was possible. The average age of the tree layer was 57 years. The size structure of the tree and shrub layers did not demonstrate any regular patterns, which may suggest that the slope was getting overgrown all over in an erratic manner (as far as the current succession stage is concerned). An almost complete absence of the understorey, which arises from high canopy closure (70–100%), may signal that the evolution of the plant community is coming to a close (at least for this stage of succession).

Transect No. 2 features only a shrub layer formed by both full-fledged shrubs and the understorey of the future tree layer of a small-leaved forest succession stage (silver birch and aspen). Transect No. 3 has no tree or shrub (understorey) layers whatsoever.

Our findings are thus representative of the plant communities formed at different times in relatively similar conditions following the same man-made interference (dolomite mining). They shed some light on the development of sustainable communities on the slopes of dolomite quarries, charting the key succession stages.

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