Geogr. Fis. Dinam. Quat.
30 (2007), 155-159, 7 figg.

ZSUZSANNA ANGYAL (*)

LANDFORMS AND VEGETATION DEVELOPMENT ON SPOIL-TIP SURFACES NEAR SALGÓTARJÁN (NE HUNGARY)

ABSTRACT: ANGYAL ZS., *Landforms and vegetation development on spoil tip surfaces near Salgótarján (NE-Hungary).* (IT ISSN 1724-4757, 2007).

The high scenic quality of the Salgótarján physical environment is reduced by the the scars of former industrial workings in the form of conical industrial spoil tips. The material of these was accumulated as cinder and fine burnt residues of coal originated from power stations. This study examines the gemorphological stability and natural vegetational succession on two spoil cones. Distribution and areal cover of vegetation on the older cone is influenced both by the rate of degradation and exposure. More degraded, less steep slopes are already vegetated and the vegetation cover is expanding, whereas the less degraded surfaces host less vegetation cover and it consists only of herbaceous plants. As for exposure, I found that on the NW side arboreal plants characterized by water requirement are prevailing, whereas on the SW side there are herbaceous plants also with water requirement. The reason for this might be the nutrition yielded by the spoil, but further research is needed.

KEY WORDS: Iron and steel industry, Spoil tips, Land reclamation, Landforms, Vegetation, North-Hungary.

INTRODUCTION

In general, the quality of the Salgótarján physical environmental in the Zagyva valley is exceptionally high; the city nestles in forest covered hills that, locally reach as far as the city centre. However, for many decades of the19th-20th centuries, intense industrial activity polluted the area (Moser & Pálmai, 1999). The scars of this activity remain in the form of industrial spoil tips, whose characteristic, conical forms remain prominent alien, anthropogenic elements and are considered visual pollution, «eyesores» that pollute the city area. Today, it is thought that revegetation of these spoils would improve landscape quality, help transforming the city into an attractive touristic location and simultaneously revitalize the region's ailing economy. This research tackles two spoil tips located in a suburb of Salgótarján called Pintértelep. It aims to find links between the denudation of heaps, their slope exposure and vegetational succession. It compares the morphological properties of two heaps of different age and natural vegetational succession (Fekete & *alii*, 1997).

STUDY AREA

The study area, which includes an old mine and power plant, is located ca 4 km east of the centre of Salgótarján (fig 1). The spoil itself originated from the power plant, but the exact date of deposition is unknown (Varsányi, 1987). Today, two heaps of power station ash spoils survive; their relative age reflected in their degree of their erosion and revegetation.

Field observations suggest, and topographic maps confirm, that much of the spoil was dumped in a closed depression, formerly occupied by a pond of rainwater. No trace of this remains but local residents remember the pond being drained by ditches and much spoil being removed by erosion. Indeed, several centimetres of spoil deposition near the tips provide evidence of some decades of accelerated denudation (Angyal & *alii*, 2004). Local people talk of a third spoil cone, long ago removed and used for building purposes. This was probably located on the northeastern side of the depression where the plants may provide part of the seed bank for ecological succession on the heaps. The area is bordered by a coniferous plantation on the north-northeast, by remains of a wetland on the southwest and by weed growth with trees on the south-southeast.

GEOMORPHOLOGY

The refuse heaps of Salgótarján's power station have suffered severe erosion from the start. To measure this process, it was assumed that the tips began with smooth surfaces and that their morphology is a function of their original form,

(*) *Department of Environmental and Landscape Geography, Eötvös Loránd University, H-1117 Budapest, Pázmány Péter sétány 1/c, Hungary. e-mail: anzsu7@hotmail.com*

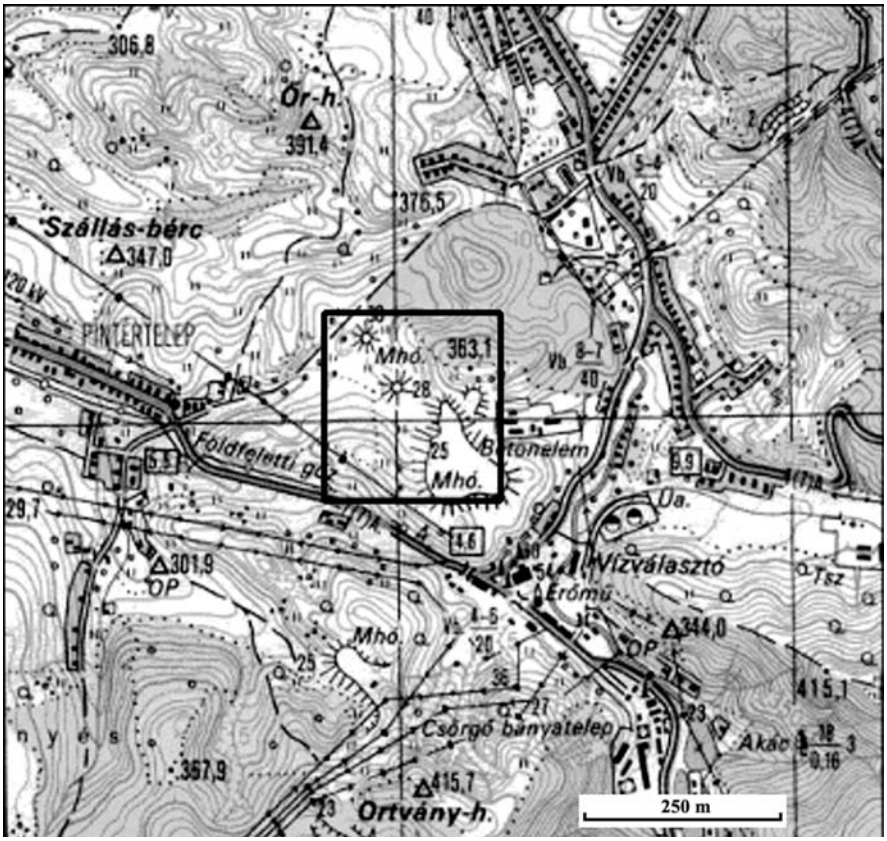

FIG. 1 - Topographic map of the study area.

their age, and the permeability of their material. Direct comparison shows that their original cone form has been much modified by exogenic processes during the last 30 years. Assessed from air photos taken in 1973, 1998 (fig. 2), and 2000, respectively, the main changes in the cone morphologies are well-developed gullies, landslides and increased complexity of the slope profiles. There are also characteristic ring-like belts separating contrasting slopes.

Parallel gullies or parasol ribbing (in the terminology for volcanic scoria cones - Cotton, 1952; Ollier, 1988) are observed only on the younger smaller heap. The heap closer to the power plant is surely older and its morphology more mature. It also supports vegetation over a much greater area. The rings separating contrasting slopes also differ in height. Possibly, these ring-like belts are the remains of slope failures involving sliding and spreading. This process could be related to rainwater infiltration and pore water pressures in the lower slopes that made these areas prone to sliding (Szabó, 1998).

The ring-like belt is found near the top of the older heap, while below are more stable and gentler slopes with few and minor gullies and much vegetative colonisation (fig. 3). On the younger cone, the sliding zone affects almost half of the cone and the higher levels of the heap are severely gullied.

Vegetational colonisation is progressing across the lower slopes of this second, younger, cone but it is far less advanced than on the older cone (fig. 4). Probably, the

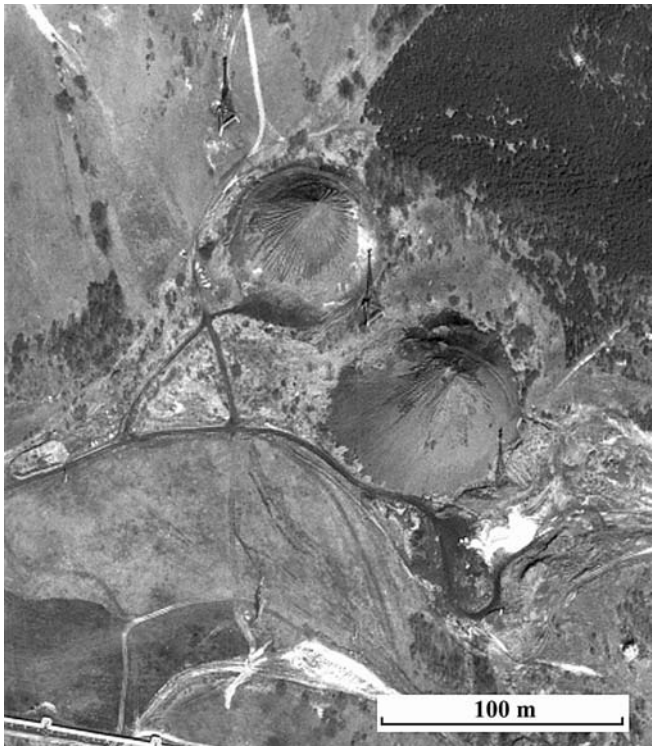

FIG. 2 - Aerial photo of the slag heap from the year 1988 (Photo courtesy of Remote Sensing Centre of the Institute of Geodesy, Cartography and Remote Sensing).

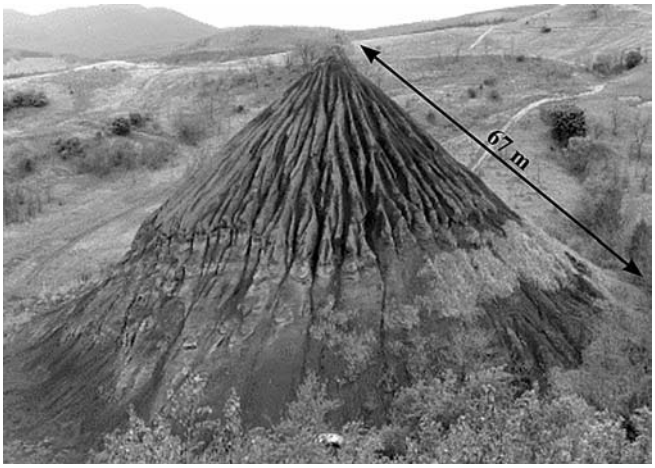

FIG. 3 - The surface of the younger, northeastern cone with a slump zone in the middle. By now this zone has completely shifted to the top in the case of the older cone.

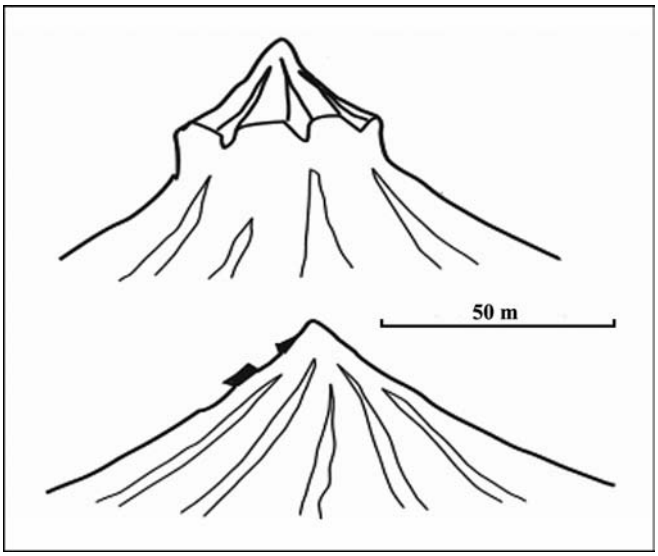

FIG. 4 - Morphological differences in the surfaces of the two piles of dross.

slump zone is gradually migrating uphill due to sliding, while vegetative colonisation is suppressing erosional procession on the lower gentle slopes.

Significant differences can also be observed in upper parts of the two heaps. On the older cone, a prominent remnant surface points to the existence of a previous cone surface. Since the width of this relic is 1.8 m, it may be that the cone was once 1.8 m wider in diameter, and that its volume has been diminished by the erosion of the corresponding amount of material. On the younger cone, the upper parts preserve the original height and surface of the cone, albeit with modification by the severe gully erosion above the slump zone. However, here any loss of volume seems due to erosion rather than any decrease in cone height. Yearly, a bit more than 0.3% has been eroded from the cones on the average, that is, approximately 1000-1100 m^3. Of course, because it is only an average figure, it is bigger in the humid years and smaller in the arid years, and the slides might be momentary events.

VEGETATIONAL SURVEY

Two NW-SE transects were recorded across the most densely vegetated areas of the opposing slopes of the older heap starting from the bottom of the heap up to the level the vegetation has reached upslope (80 m on the NW and 45 m on the SE slope). Plant species were recorded at every five metres of a two-metre wide strip. The coverage of dominant species was also estimated and this change of vegetation and species diversity described. From an ecological and nature conservation point of view it is important to know the naturalness of the vegetation as well its species composition and spatial structure. The survey evaluated the categories of Borhidi (1993) but only the naturalness values (SBT) are presented here. Since the younger heap has fewer plants, which are restricted to the lowest slopes a similar detailed survey was not undertaken However, dominant species of the narrow vegetation zone on the younger cone are: Chee reedgrass (*Calamagrostis epigeios)*, various ruderals and Scotch fir (*Pinus sylvestris*) seeding in from the planted forest nearby. The great question is when will classical plant communities develop and can they be the base of landscape rehabilitation or biotope restoration plans in the future?

Older Cone - Southeastern slope

Here, the vegetation cover is continuous to 45 m height and includes 26 species. The lower slopes are richer in drought resistant and disturbance tolerant species. Chee reedgrass is conspicuous with high frequency and large cover up to 15m. In addition, water loving plants appear, like reed (*Phragmites australis*), hemp agrimony (*Eupatorium cannabinum*) and *Solanum dulcamara* (fig. 5).

Upslope, reeds become more common but smaller in size Giant goldenrod (*Solidago gigantea*) and its seedlings appear in large numbers. This plant is one of the most common, and aggressive alien species in the Carpathian Basin. Such alien ruderal species can quickly become dominant and occupy a biotope for a long period, which hinders the natural succession processes (Standovár-Primack, 2003).

Between 15 and 20 m, dominance changes from reedgrass to reeds, which grow to heights of 1.5-2 m and smother the entire surface. Hops (*Humulus lupulus*), a characteristic species of the riparian forests, climb up the reed. Beneath the reed, seedlings of thistle (*Cirsium arvense*), *Arctium lappa* and hemp agrimony grow on the slag surface. Some seedlings of Turkey oak (*Quercus cerris*) also appear as well but few survive in the reed's shadow. As reed becomes dominant, Chee reedgrass declines.

FIG. 5 - Vegetation on the southeastern slope of the older heap (photo by M. Virág).

Further along the slope, Chee reedgrass is the dominant (90 per cent cover) with some thistle. Above 45 m, there is little permanent vegetation, just patches of Chee reedgrass up to the 57 m. Under dense vegetation, humus has accumulated to a depth of 10-15 cm.

Older Cone - Northwestern slope

This is the more densely overgrown side of the older heap. Vegetation extends upwards to 80 m are there are many more species than on the southeastern slope (fig. 6): a total of 59 have been registered. Both of the slag heaps were deposited on the side of a small, formerly wet, bowl-shaped valley. It is evidenced by some remaining species like white willow (*Salix alba*), glossy buckthorn (*Frangula alnus*), lesser pond sedge (*Carex acutiformis*), nettle (*Urtica dioica*), bluegrass (*Poa pratensis*), white panicle aster (*Aster lanceolatus*) as well as the already mentioned hop, hemp agrimony and giant goldenrod. The northwestern slope of the studied slag heap rose directly from this former wetland, which is why such species could easily colonize it.

The lower 15-20 m zone of the transect is forested with 5-6 m high species like Scotch fir, European aspen (*Populus tremula*), silver birch (*Betula pendula*), goat willow (*Salix caprea*), sessile oak (*Quercus petraea*), Turkey oak (*Quercus cerris*), hawthorn (*Crataegus monogyna*), European privet (*Ligustrum vulgare*) and Robinia (*Robinia pseudo-acacia*). The herbaceous layer here, as on the southwestern slope, is dominated by Chee reedgrass as well as the former wetland species: hop, climbing nightshade *(Solanum dulcamara)* and hemp agrimony. Species richness is greatest between 15 and 25m. Moving upslope, the dominance of the Chee reedgrass decreases and above 40 m, it is found only in small patches. Here, there is an abundance of giant goldenrod and a new species, coltsfoot *(Tussilago farfara),* characteristic of disturbed biotopes, appears. The formation of a humus accumulation on the soil surface is appreciable up to 55-60 m, while, mosses and lichens are well represented, including juniper haircap moss *(Polytrichum juniperinum)*, a species indicating soil acidity.

FIG. 6 - Vegetation on the northwestern slope of the older heap (photo by M. Virág).

Above 65 m, the dominance of woody plants is declines and herbaceous plants dominate. A purple willow *(Salix purpurea)* seedling was found at 75 m height, while three species: Chee reedgrass, coltsfoot and Scotch fir seedlings reach to 80 m.

NATURALNESS OF VEGETATION

These are the followings which are well documented on figure 7. From the figure it is obvious, that on both slopes of the slag hap the *disturbance-tolerant natural species* (DT) are the most common (28-30 per cent). The abundance of *generalists* is almost twice as high on the northwestern slope, while *natural weeds* are more common on the southeastern slope (SE: 19 per cent, NW: 15 per cent). *Ruderal competitors* (RC) are three times more common on the southeastern slope but *competitors* (C) are similar (12 - 15 per cent). *Natural pioneers* (NP) and *invasive* species (AC) are similar on both slopes. There is a sin-

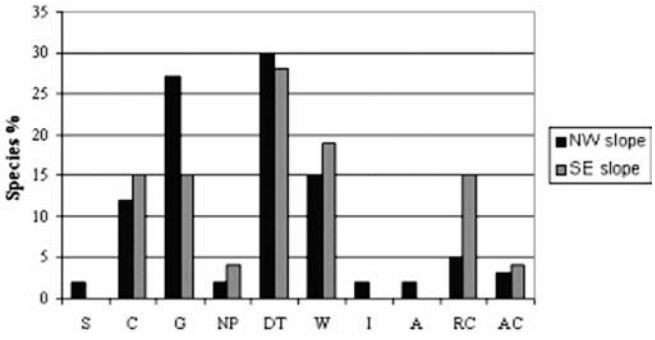

FIG. 7 - The naturalness values of plant species on slag heaps. *S: Specialists; C: Competitors; G: Generalists; NP: Natural pioneers; DT: Disturbance tolerants; W: Weeds; I: Introduced alien species; A: Adventives; RC: Ruderal competitors; AC: Agressive alien species or invadors.*

gle species representative from the classes of *specialists* (S), *introduced alien species* (I) and *adventive* (A) plants - on the northwestern slope of the slag heap.

CONCLUSION

The geomorphological observations of spoil tips allow the reconstruction of the erosion occurred in the past thirty years. As a result, apart from rill erosion, the slides that expand on the cone surfaces also play an important role. Regarding the latter, based on the present cone dimensions and on the volume of rills of the cones, there is a calculation of the eroded material and the average erosion rate. In the past 30 years approx. 10-15% of the cone volume has been removed, implying serious environmental risk.

The recovery of the vegetation might play an important role in reducing pollution. That process, however, is going on mostly on the older cone surfaces only. Changes in vegetation cover have been detected with the help of air photos. The plant composition was classified on both cones, taking into consideration also the differences according to the exposure. On the basis of ecological values, it has been concluded that the surface of the slag banks are colonised by weed species having a character of ruderal habitat, and other one-year species, all forming typical succession. Subsequently, perennial herbaceous as well as arboreal plants also appear. On the studied slag cones only spontaneous recovery of the vegetation is taking place. As a consequence, the vegetation is strongly mixed, but very unique, having no similarity to other characteristic associations.

In the near future, it is expected that species will also appear on the lower flanks of the cones, because the material has been accumulated on the flat, closed depressions surrounding the cones, where species living on typical wet habitats could survive.

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(Ms. received 25 December 2006; accepted 30 November 2007)