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Serpentine soil and plant diversity, with emphasis balkan Peninsula

Abstract

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Serpentine is formed during chemical transformation of ultrabasic magmatic rocks. The characteristics of serpentine soil are its high Mg and low Ca content. Various factors have lead to the formation of specific serpentine flora and vegetation. In the serpentine flora both basophilous and acidophilous plant species are present, and a small number of families and often genera predominate. Most species growing on serpentine soil tolerate the hostile edaphic factors by concentrating low Ca quantities in their tissue, to protect themselves from toxic metals. Generally, the serpentine flora is relatively poor in species as well as individuals. Many species are represented by particular races on serpentine. Obligate serpentinophytes occur only on open spots on ultramafic rocks. The unfavorable, selective soil of Serpentine areas contributes to the floristic wealth of the Mediterranean region, which is one of the major centres of plant diversity.

Introduction

Serpentine is a collective term that applies to three minerals: antigorite, lizardite and chrysolite. The differences in chemical composition of serpentinized rocks are many, and rock specimens come in a wide range of attractive, pure or mixed shades of red, green, blue and black. All three minerals are produced by the hydration of the ferromagnesian minerals in ultramafic rocks. Hydration of the ultramafic protolith occurs at temperatures of less than 500°C. Serpentinized ultramafics are found in many parts of the world and are often associated with an unusual flora with rare, endemic, relic species and deviating ecotypes.

Serpentine soil and plant life

The significant influence of ultramafic geology on plant life provokes many questions which physical, chemical and biological factors change plant cover, characterized by specific vegetation and by floristic richness in endemism, indicator species, races etc. It is not properly known how these three complex factors do interact to give a "serpentine syndrome".

Plant growth on ultramafic soils can be looked at in terms of nutrient status in the soils, themselves. Plant species intolerant of ultramafic soils are thought to be either deficient in essential nutrients or sensitive to toxic levels of Mg and heavy metals, (Kruckeberg 1992).

As suggested by Jenny (1980), survival on serpentine soil is a summed response to several, physical and chemical factors. Tolerance to ultramafic or any other habitat is the product of evolutionary accommodation to various ecological factors.

A very important aspect of investigation of serpentine flora is chemical analysis of soil and metal uptake by serpentinophytes. Serpentine soil is characterized by toxic concentrations of metals (Mg, Ni etc.). Some species are resistant to metal toxicity (Babalonas & Reeves 1988, Sieghardt 1990). Babalonas & al. (1984), analysing several species from different families (*Lamiaceae*, *Caryophyllaceae*, *Scrophulariaceae*, *Brassicaceae*, *Asteraceae*, *Polygonaceae*), showed that each species reacts differently to each different chemical constituent of the serpentine soil. Moreover no general rule can be deduced about the absorption capacity of each single species and single parts of the plants with respect to each single element. However, in most cases, the leaves accumulate higher quantities of Ca, Mg, Fe, Ni and Mn than the shoots. Analysis of *Caryophyllaceae* representatives growing on metalliferous soils showed that the Ca concentration is much higher in the plants than in the soil, (Konstantinou & Babalonas 1996). In particular, the Ca/Mg ratio, which is in most cases lower than 1 in the soil, is much higher in the plant tissue.

Serpentinomorphoses

Many plants growing on serpentine soil show some morphological characteristics deviating from the typical species on nonserpentine soil. These changes, serpentinomorphoses, have arisen in different genera independently. Pichi-Sermolli (1948) recognized the following changes: stenophyllism, glabrescence, plagiotropism, nanism, macrorrhyzy and glaucescence.

Serpentinomorphoses are adaptations to intense light, dry microclimate and low nutrient content (Pichi-Sermolli 1948), that include both hereditarily fixed deviations persist under cultivation in normal soil and non-hereditary modifications.

Characteristics of serpentine flora

Rune (1953) pointed out that several features are common to at least serpentine floras of the North:

Serpentine flora is relatively poor both in individuals and in species. This could apply to open vegetation on skeletal soil. In the Balkan Peninsula *Eryngium serbicum, Potentilla visianii, Fumana bonapartei, Scorzonera serpentinica* etc. are represented by very few individuals. However, in the grasslands the number of species and individuals is relatively high.

On serpentine, several species are represented by particular races differing ecologically and sometimes morphologically from the typical representative of the species. This is true for all serpentine habitats in the world. Tatić (1969) presented several taxa from Serbia possessing serpentinomorphoses at various taxonomical ranks.

Many plants occur very disjunctively on serpentine. Proctor & Woodel (1971) showed that some species such as *Arenaria norvegica* subsp. *norvegica, Asplenium viride,* *Cerastium arcticum* subsp. *edmondstonii,* etc., have disjunction of 80 km or more. For Balkan Peninsula good examples of disjunction are *Forsythia europaea* and *Minuartia baldaccii.*

The serpentine flora contains both basophilous and acidophilous plants. Rune (1953), recorded basophilous (e.g. *Asplenium viride* and *Silene acaulis*) and acidophilous plants (*Calluna vulgaris* and *Deschampsia flexuosa*) in N. Sweden. These species also grow in the Balkan Peninsula.

The serpentine flora has a relatively xerophytic character. Proctor & Woodel (1971) showed that some species on ultramafic substrata have xeromorphic characters; also Petković & al. (1997) found these characteristics in *Verbascum phoeniceum* on serpentine soil.

The serpentine flora is often dominated by certain families of genera. *Caryophyllaceae* family are often dominating in N. Europe and NE America. This, referring to the flora of skeletal soils in general. However, in South Europe important families on serpentine are also *Fabaceae*, *Asteraceae*, *Poaceae* and *Ericaceae.*

Serpentinophytes of the Balkan Peninsula

According to Tatić & Veljović (1992) the number of obligate serpentinophytes occurring in the Balkan Peninsula is smaller than it is reported in Flora Europaea. These are: *Alyssum markgrafii, Asplenium adulterinum, A. balcanicum, A. cuneifolium, A. smolikanum, Bornmuellera dieckii, Fumana bonapartei, Gypsophila spergulifolia, Halacsya sendtneri, Haplophyllum boissierianum, Onosma elegantissima, Onosma euboica, Polygala dörfleri, Potentilla visianii, Saponaria sicula* and *Sedum serpentinii.* Other possible obligate serpentinophytes are to be found by specific studies. As regards the serpentinophytes of Serbia, they have recently been investigated under the morphological and anatomical (Petković & al. (1996, 1997), phytochemical (Janaćković & Tešević 1995, Marin & al. 1996) and karyological (Topuzović 1995) aspects.

Vegetation

Generally, vegetation on serpentine soil varies remarkably in various localities and regions forming distinctive variants of conifer or mixed conifer-hardwood forest, chaparral or grassland. The serpentine vegetation is distinguished from neighbouring nonserpentine, both by species composition and by physiognomy .

Serpentine vegetation Balkan Peninsula is heterogenous. Many papers were published and plant communities specific to ultramafic habitats were described. Some communities on deeper ultramafic soils on gentle slopes and flat terrains are not restricted to ultramafic soils. Much more work is required to establish which communities are truly restricted to ultramafic soils. There are many forest and shrub phytocenoses (*Abieto-Fagetum, Calluno-Quercetun serpentinicum, Erico-Abieti-Fagetum, Erico-Pinetum nigrae, Erico-Quercetum petraeae, Fago-Abietetum serpentinicum, Piceetum* etc.), as well as meadow, pasture and stony ground phytocenoses (*Agropyretum juncei mediterraneum, Artemisio-teucrietum montani, Bromo-Chrysopogonetum grylli, Centaureo-Bromion fibrosi,* *Convolvulo-Festucetum vallesiacae, Danthonietum calycinae, Diantho-Sesslerietum latifoliae, Erysimo-Sempervivetum heuffelii, Euphorbieto-Fumanetum bonapartei,...*). The major groups are composed by phytocenoses of deciduous forests, evergreen forests, meadows and pastures, and stony habitats. There is still a lack of investigations on the most open habitats on ultramafic rocks.

Successions on ultramafic and conservation of serpentinphytes

One of the most important questions regarding ultramafic soil is succession of flora and vegetation. Many authors stated that succession on this soil is very slow because of chemical, physical, historical and anthropogenic factors. Thus, Proctor (1992) concluded that the main causes for this slow or negligible succession on most British ultramafics are: low soil nutrient concentrations, high soil Mg/Ca quotients, high soil nickel concentrations, adverse physical factors and interactions between these factors.

In the Balkan Peninsula the plant cover on ultramafic substrates is heterogenous. Many ultramafic substrata were earlier under forests. Anthropogenic activities are evident. In serpentine forests are replaced by meadows, pastures, steppes, rocky and barren grounds.

On some serpentine massifs, such as Gostovic mountain (BiH), Golija, Goè, KodΩa Balkan, Studena mountain (Serbia), several mountains of Albania and some in Greece there are still well preserved forests. When forests disappear, meadows, pastures, and barrens rocky grounds develop. Floristically, the grasslands that develope on flat lands and gentle north-facing slopes are similar to meadows. The dominant species are *Cynosurus cristatus, Agrostis vulgaris* and *Chrysopogon gryllus*. For south-facing meadows with deeper soils characteristic species are *Andropogon ishaemum*, *Festuca* spp., *Danthonia calycina, Poa molineri, Sesleria rigida, S. serbica* and others.

The vegetation of degraded rocky ultramafic grounds is similar on steep and dissected areas in hilly regions at low altitudes with slightly rounded relief and on gentle slopes of ultramafic areas in Greece, Albania and in central parts of Serbia and BiH. For example, the massive of Vourinos mountain in the region of Kozana is composed entirely of ultramafic rocks. It was deforested and degraded into rocky ground where some species of *Quercus coccifera, Q. pubescens*, *Fraxinus ornus* forests occur as well as many species of shrubs and perennial plants. Typical ultramafic open rocky habitats are distinct by many of obligate serpentinophytes which are a substantial proportion of the plant cover. It seems that the more unfavorable the conditions the greater the role of serpentinophytes. On ultramafic soils, especially on stony soils, plant cover increases slowly since erosive effects are severe. In the re-establishment of forest cover an important role is played by the remaining fragments of the forest floor. In Serbia, Macedonia, Albania and Greece, on rocky open ultramafic habitats *Rhus cotinus, J. oxycedrus* and *J. communis* are noted as important pioneer species. *Prunus, Malus, Cytisus, Rosa, Crataegus, Coronilla* species may also play a pioneer role on ultramafics. On burnt areas this role is mainly attributable to some species of *Salix, Sambucus* and *Rubus*. Herbaceous plants colonize burnt areas on ultramafics at a slower rate than on other substrates. In open areas with serpentinophytes, succession seems to be arrested. Serpentinophytes grow either in rosettes or lying on the ground or as tiny shrubs. Although their total cover is small they are of importance for erosion protection and natural reforestation on these areas does not occur.

Future research

In spite of the great number of works so far published on the serpentine habitats, they are still very interesting for botanists. Rune (1953) indicated both the occurrence of lichens and moss variability on this type of soil. This field needs much more investigation. In serpentine flora of Serbia bryophytes are very rare, but still uninvestigated. Some investigations are in progress. Vascular plants are partially investigated. The investigations of morphological, anatomical and physiological adaptations and their taxonomic relevance need a long time experimental and field work for many species. The problem is that the species, even within the same genus or family, possesse their own adaptation. (Vergnano Gambi 1992) suggested that it would be interesting to investigate occurrence of C-4 plants and anatomical differences between C-4 and C-3 plants. Also, it would be of interest to investigate different tolerance mechanisms in serpentine plants and accumulation of toxic metals such as chromium, nickel and cobalt. Many plants possess exclusion mechanisms and their physiology and enzymology is required, because of their biochemical pathways which led to accumulation and compartmentation of metal, Vergnano Gambi (1992). Biological consequences of the sharp differences are expected to be investigated from fundamental aspects in the field of ecophysiology, population genetics and molecular biology.

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