CO_3Sols

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Introduction

The carbonation/decarbonation processes have a very important role in the formation of many soils, especially in the subhumidic and subaridic zones. It is well known when the rainfall infiltrate the soil, the water enrich in CO_2 transforms the calcium carbonate (insoluble) in bicarbonate (soluble), the latter is redistributed by the soil horizons and when the solutions concentrate (by evaporation or absorption by the roots of the plants), precipitates forming secondary accumulations.

This is an interactive computer programme for demonstration of macro and micromorphological aspects of carbonatation/decarbonatation processes in soils. This software belongs to a course developed for the soil-genesis teaching. Some computer other programs of this course are presented in this Eurosoil 2004: OpticalMine, SoilMicroscopy, IlluviaSols, CO_3Sols and HydroSols.

The application

CO_3Sols has been re-worked using the heterogeneous (Windows, Mac, Linux, etc) languages HTML and JavaScript from a first version implemented in Hypertalk for Apple Macintosh computers, which was presented in the 10th International Working Meeting on Soil Micromorphology (Dorronsoro et al., 1996) and in the 16th World Congress of Soil Science (Dorronsoro et al., 1998).

The program is available in both English and Spanish versions and it can be found at:

http://edafologia.ugr.es/carbonat/indexw.htm

CO_3Sols is a composed of texts, figures and microphotographs, the user will have to answer some questions concerning the identification of a mineral, which is shown in a picture. Thus, the software evaluates the knowledge of the student.

The presented software allows both the self-learning of the students and their self-evaluation. For the self-evaluation of the knowledge acquired by the student, test suite is provided. Additionally, the students can be calificated with this software; the highest score is 10 points and each wrong answer is penalized by two points.

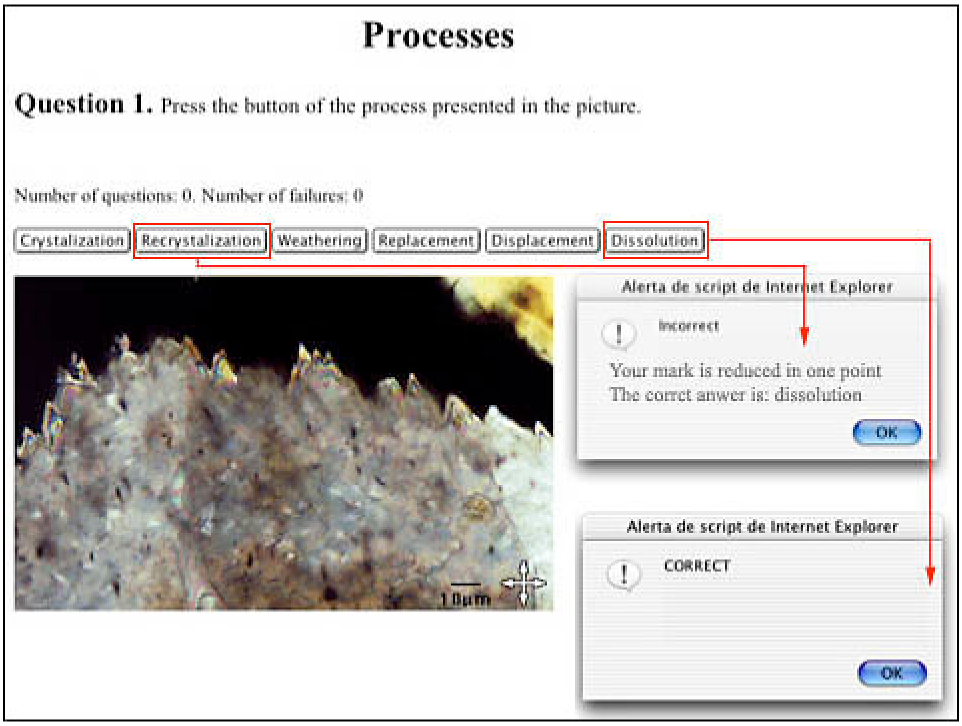

Figure 1. Evaluation test

Some scripts related to the Figure 1 are given below.

Script 1

```
<html>
<head>
<meta http-equiv="Content-Type" content="text/html; charset=iso-8859-1">
<title>Test 1. Question 1.</title>
<SCRIPT LANGUAGE="JAVASCRIPT" src="js/pt1.js"></SCRIPT>
</head>
<body>
<p align="center"><strong><font size="5"><strong>Processes  test </strong></font></strong>
</p>
<p align="center"></p>
<p align="left"><font size="4">Question 1. Press the button of the process
    presented in the picture.</font></p>
<p align="left"><img src="recursos/prtest1.gif" width="450" height="280"></p>
<FORM>
  <p align="left">
   <input type="button"  name="WindowButton1"  value= "Crystallization"  onclick="b1()">
   <input type="button"  name="WindowButton2"  value= "Recrystallization"  onclick="b2()">
   <input type="button"  name="WindowButton3"  value= "Wheathering"  onclick="b3()">
          <input type="button"  name="WindowButton4"  value= "Replacement"  onclick="b4()">
   <input type="button"  name="WindowButton5"  value= "Displacement"  onclick="b5()">
   <input type="button"  name="WindowButton6"  value= "Dissolution"  onclick="b6()">
  </p>
 </FORM>
</div>
</body>
</html>
```

Script 2

```
// JavaScript Document

function a()
{
open("pt1ra.htm"); self.close();
}
function e(){
open("pt1rb.htm"); self.close();
}
function b1() {
window.opener.nota=window.opener.nota-1;
window.opener.resultados += "\nCrystallization; Replacement =>  NOTA: "  + window.opener.nota;
e()
 }
function b2() {
window.opener.nota=window.opener.nota-1;
window.opener.resultados += "\nRecrystallization; Replacement =>   NOTA: "+ window.opener.nota;
e()
 }
function b3() {
window.opener.nota=window.opener.nota-1;
window.opener.resultados += "\nWeathering; Replacement =>   NOTA: "  + window.opener.nota;
e()
 }
 function b4() {
window.opener.nota=window.opener.nota+1;
window.opener.resultados += "\nReplacement; Replacement =>   NOTA: "  + window.opener.nota;
a()
 }
function b5() {
window.opener.nota=window.opener.nota-1;
window.opener.resultados += "\nDisplacement; Replacement==>   NOTA: "  + window.opener.nota;
e()
 }
 function b6() {
window.opener.nota=window.opener.nota-1;
window.opener.resultados += "\nDissolution; Replacement =>   NOTA: "  + window.opener.nota;
e()
 }
```

The program has 121 pages with 241 pictures and it has a size of 42.4 MB.

A specific high-security navigator (soile v.1.0) has been developed to examine students; our navigator does not allow some non-desired options of usual navigators (navigator menu, refresh of the current page, access to the source code, access of the history of visited pages, etc), and it provides automatic recording of the results (Figure 2).

Figure 2. Configuration options.

The programme is divided in seven parts:

1. Introduction. The first part explains the properties used to identify carbonates with the polarizing microscope (e.g. relief, colour, pleochroism, habit, interference colours, extinction, elongation, axial figures and optical sign), as well as a general concept about the process of calcification in soils (parameters, cause, distribution, translocation, precipitation, factors and origin).

2. Macromorphological aspects. The features presented in the accumulations of carbonates in the soil profile are explained here (colour, distribution, ClH reaction, cracks and voids, nodules, ped coatings, gravel coatings, ...).

3. Carbonates micromorphology. In this chapter, the microscopic features of the carbonates in soils are analyzed: coatings, hypocoatings, infillings, nodules, and finally the groundmass (Figure 3), according to Bullock et al. (1985).

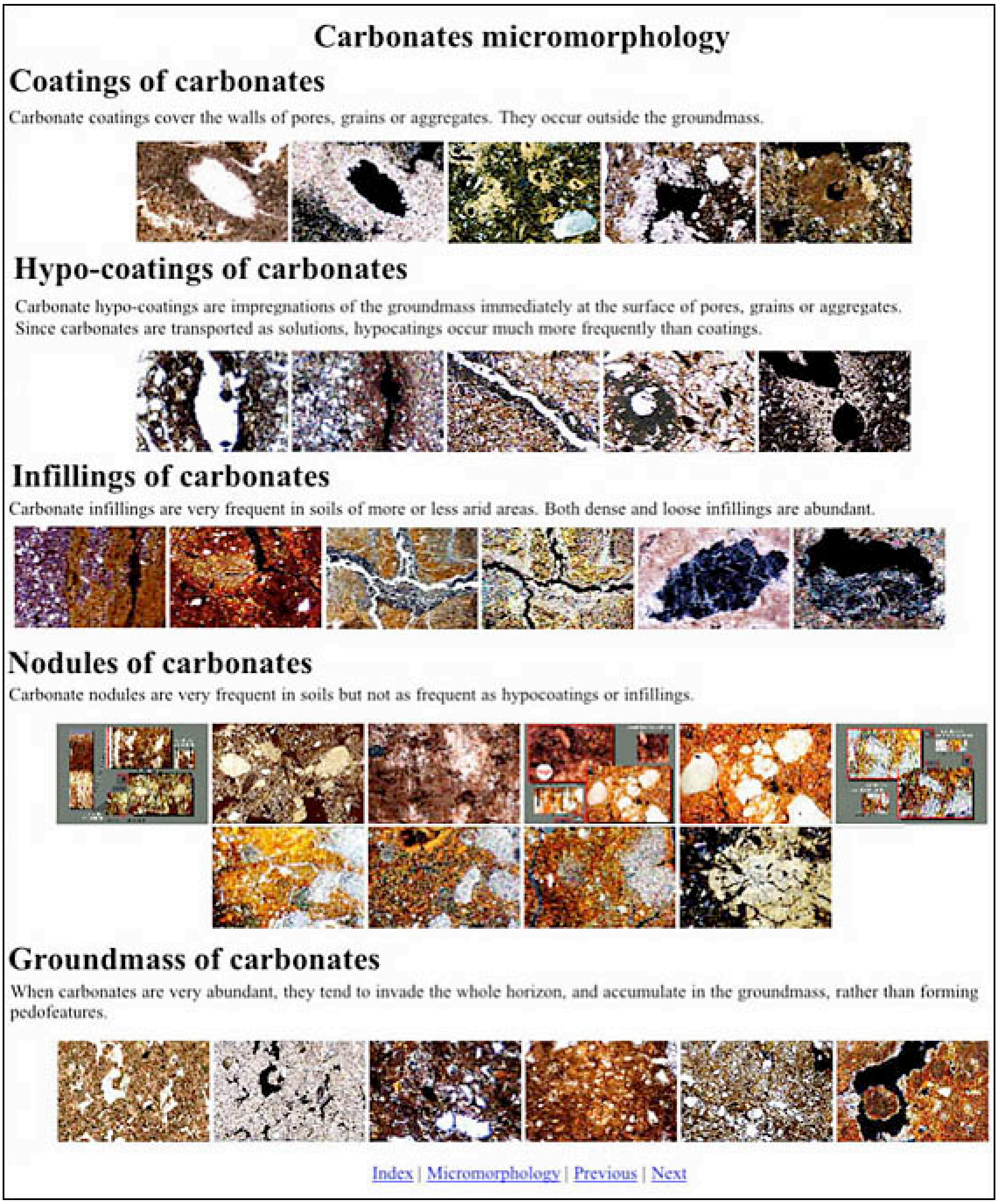

Figure 3. Micromorphological aspects.

4. Calcic horizons. The accumulation of pedogenic carbonates in the "k horizons". Calcic and petrocalcic horizons.

5. Processes. The part on processes treats: calcite formation including crystallization, alteration and bioformation as primary processes, and recrystallization, replacement as secondary processes (Figure 4). In addition calcite destruction (dissolution) is discussed.

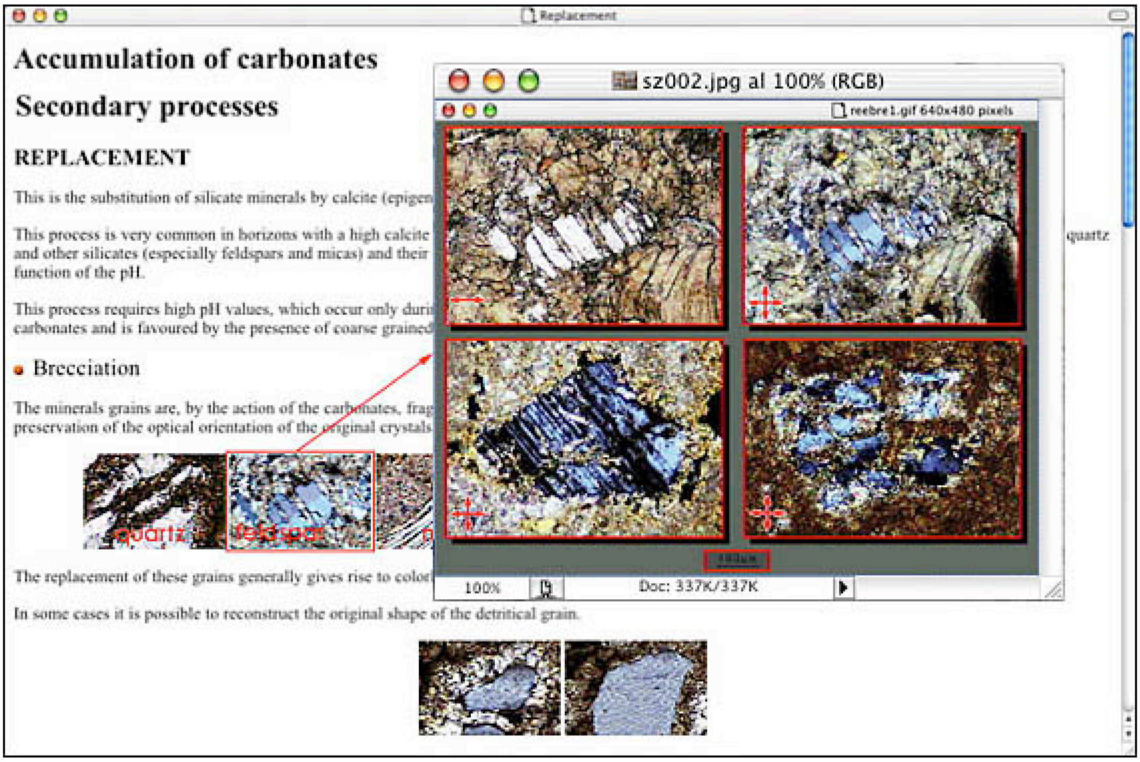

Figure 4. Secondary processes, replacement

6. Evolution. The carbonates represent a very active phase, since they remain affected by pedogenic processes, for which they frequently show a determined evolutional tendency. In general carbonates are being to accumulate subsequently in specific horizons along the time. The type of accumulations, their morphology as well as the resulting genetic processes will change with the age of the soil.

7. Origin. Carbonates are dominantly derived directly from the parent material and occasionally they are formed by weathering of minerals present in the parent material (in both cases they are said to be autochthonous). In other cases the carbonates originate from external sources, e.g. transported by wind or water (allochthonous).

Soil carbonates are subject to mobilization processes which leach them from the surface horizons. From a genetic point of view it is of great interest to distinguish a possible pedogenic origin (i.e. a vadose origin) of these accumulations from a geological provenance (i.e. freatic) of the carbonates of the parent material. In this chapter, the macroscopic and microscopic features of the carbonates from different origins are revised.

Didactic evaluation

The program has been evaluated by a group of students and the results are summarized in Table 1. The evaluation reveals the high acceptance and the good marks obtained, so the method is considered as highly effective.

Acceptance by the student	
Evaluation of the practices	
Very satisfied	74 %
Satisfied	16 %
Acceptable	5 %
Disagreement	4 %
Very disagreement	0 %
No opinion	1 %
Attainment of objectives	
Totally	53 %
Enough	20 %
Sufficient	17 %
Scarce	8 %
Null	0 %
No opinion	2 %
Marks obtained	
First class	48 %
Second class	25 %
Pass	21 %
Fail	6 %
Population	146 students

Table 1. Results of the evaluation test made by the students.

References

BULLOCK, P.; FEDOROFF, N.; JONGERIUS, A.; STOOPS, G. y TURSINA, T. 1985. Handbook of soil thin section description. Waine Research Publishing, Albrighton, U.K.

DORRONSORO, C.; AGUILAR, J.; FERNANDEZ, J. 1996. Interactive computer programme for demonstration of micromorphological aspects of calcification processes in soils. 10th Int. Working Meeting on Soil Micromorphology. Moscow. Russia.

DORRONSORO, C.; AGUILAR, J.; FERNANDEZ, J. 1998. Carbonate in Soils. 16th World Congress of Soil Science. Montpellier. France.