THE PILOT PROJECT OF THE MINERAL COLLECTIONS FROM THE UNIVERSITY OF BARCELONA

An opportunity to create updated teaching material to be shared with other universities

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1. RESUM:

The Mineralogy teaching collection from the University of Barcelona has proved to be a successful tool for students. The urge of its renewal to meet the necessities of modern industry brought the idea to replicate this collection in order to offer high quality teaching material to other universities worldwide. This project has led to an international collaboration aiming to enhance international solidarity among universities and make evident the importance of Mineralogy in Geology studies.

2. ABSTRACT:

The Mineralogy teaching collection from the University of Barcelona has proved to be a successful tool for students. The urge of its renewal to meet the necessities of modern industry brought the idea to replicate this collection in order to offer high quality teaching material to other universities worldwide. This project has led to an international collaboration aiming to enhance international solidarity among universities and make evident the importance of Mineralogy in Geology studies.

3. PARAULES CLAU: 4-6

Mineralogy, collection, international network, teaching material, geology, students

4. KEYWORDS: 4-6

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5. DESENVOLUPAMENT:

Introduction

An in-depth reorganisation of the Mineralogy teaching collections was conducted at the University of Barcelona (UB) 30 years ago. This teaching collection has now about 1500 hand samples (fig. 1), 1000 thin sections (fig. 2) and 500 polished sections for hands-on sessions. In addition, numerical exercises on the interpretation of XRD and EMP analyses were designed.

The practical sessions are regarded not as complement to theory but as an autonomous entity. Therefore, the lessons are organised according to mineral assemblages (and not according to mineral classification) for most common rock types. The goal of this itemisation is to instruct the students with key observations in order to identify the minerals hosted in different rock types and ores. For instance, one session is devoted to minerals in granitic rocks and students learn how to identify quartz, K-feldspar, plagioclase, muscovite, biotite, cordierite, almandine, and hornblende in granitic assemblages. Minerals are disposed on drawers containing from 5 to 30 samples showing different representative aspects for every mineral in each association. Samples are classified according to their identification difficulty. For example, for hornblende, the first sample consists of a perfectly crystallized euhedral single crystal specimens (fig. 3), the second one includes crystals within a rock (fig. 4), the third one are cleavaged crystals within a rock, then fine-grained crystals within a rock, then altered crystals and so forth. Another example, for stibnite, we obtained samples representative of the most important aspects of the mineral: a) single crystals (fig. 5), b) radial aggregates (fig. 6) and c) massive columnar aggregates (fig. 7). The student is handed out a manual with the descriptions of every sample or section.

Putting together such a comprehensive collection has been a continuous effort that has been well rewarded; most of our students achieve a high level in Mineralogy. However, after 30 years of uninterrupted use, many samples have been damaged and a renewal and update of the collection is imperative. In order to do so, the lecturers involved are selecting the most didactic samples from well-known localities worldwide.

The UB is engaged in a project together with the Universidad Nacional Autónoma de Mexico (UNAM) on the creation of renewed hands-on sessions of Mineralogy for several months now. Keeping up the momentum to renew the collections from both institutions, we have started an international pilot project to provide other universities worldwide with equivalent (cloned) collections. Hence, the UB has already contacted 20 universities worldwide to participate in this pilot project. It has been also considered that, after a trial period in order to verify the results of the project, the same will be proposed to other universities. Moreover, if the experiment is successful, the scope of the cloning could be expanded into other subjects within Earth Sciences, such as Petrology or Palaeontology.

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The aim of this contribution is to explain the pilot project of cloning the teaching mineral collections of the University of Barcelona.

Identification of the objectives of the pilot project of renewal and cloning of the teaching collections

A first step was to list the minerals to be taught in the regular teaching sessions at the University of Barcelona, in order to ensure a new collection adapted to the demands of the 21st century industry: when the current collection was created in 1980, there was no interested in In, Ge, Ta, Nb, REE, etc. (see http://ec.europa.eu/growth/sectors/raw-materials/specific-interest/critical_es), which today are regarded as "critical elements" by the European Commission. To achieve these objectives, we selected a list of 222 mineral species and varieties, embracing both academic (as rock forming) and industry (as ores) interests. The list comprises 44 native elements, sulphides and sulphosalts (table 1), 47 halides, oxides and carbonates (table 2), 34 sulphates, borates, phosphates, arsenates, wolframates (table 3), 51 tectosilicates, cyclosilicates and inosilicates (table 4), and 46 phyllosilicates, sorosilicates and nesosilicates (table 5). We consider that every Geology student worldwide should learn of the existence of these minerals (first column in the tables).

In a second stage, we defined a mineral list which includes all species that the students must recognise in hand sample and/or in thin/polished sections (minerals indicated in bold characters in the first column of the tables). To ensure that, besides of the academic interests, the selected minerals also cover the needs of the mining companies, and are aimed to be agreed with representatives of the Society for Geology Applied to Mineral Deposits (SGA) and Society of Economic Geologists (SEG).

In a later stage, we established an additional list with the aspects that different species or varieties should ideally present. The most important species (in bold in the tables) require several samples covering the different characteristics that they present in different contexts (i.e., variations in crystal habit, grain size, colour, alteration, types of aggregates); and at least one sample is needed for the least important minerals.

Defining the aims of the proposal

The project comprises the following objectives:

- To renew the teaching mineral collections (minerals in hand sample, thin sections, polished sections) of the University of Barcelona.
- To prepare the corresponding new guidebooks for the renewed mineral collections at the University of Barcelona.
- To reproduce (clone) all the Mineralogy teaching materials (collections, exercises, mineral

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descriptions, etc.) used at the University of Barcelona and to create a warehouse with the collections (including the best specimens to be used for teaching).

- The replicated (cloned) material should comprise: a) representative hand samples of the 222 species and varieties selected, and b) rock pieces of the above species suitable to prepare thin or polished sections (the corresponding thin/polished sections will be prepared using these samples at the universities of destination).
- To translate the guidebooks, the numerical problems and the other teaching material (originally in Catalan, to Spanish and English). The receivers should translate them to other languages when necessary (Portuguese, Chinese etc.)
- To donate this material to the participating universities, including developing countries.
- The receiving universities are free to use the material adapted to their current conditions and curricula: they can decide to use only part of the specimens according to their schedule.

The UB proposes to the counterparts to carry out the following actions:

a) To take charge, if possible, of the shipment and custom fees.
b) To store in appropriate conditions and use the material at arrival, as well as using it with due care.
c) The receiving university is asked, when possible, to contribute to the project by supplying an equivalent number of samples of good quality in order to contribute increasing the number of samples in the warehouse: the project is a collaboration based on solidarity and is not charity.

Developing the process: collecting and ordering the specimens

The most complicated task is to gather the 20.000 pieces we calculated as necessary for the lessons using hand-samples and comprising both good quality crystals and the typical widespread ("normal", massive or cleavaged) samples. As indicated before, it is important that students learn to identify different aspects of the same mineral.

Samples are obtained (or are expected to be obtained) by a combination of these methods:

a) Donations from museums (many of them from Catalonia). More than 100 samples arrived from museums.
b) Donations from private mineral collectors (mainly from the association Grup Mineralògic Català, but also from international collaborators in Canada, USA, Germany, Austria, Italy and Sweden). Up to the present moment, more than 200 samples were supplied from this source. Many of the samples are of high quality and value, e.g. native silver samples (fig. 8).
c) Donations from mining companies from Catalonia and abroad (up to 100 samples came from this source).

d) Donations from mineral dealers (many of them from Catalonia but also from international donors. Up to 300 samples from this source have been received so far.
e) Donations of academia-related individuals (including professors or students. More than 100 samples have been received.
f) Donations from collectives participating indirectly with the project, such as the Catalan firefighters (Bombers de la Generalitat de Catalunya), who contributed with more than 200 pieces.
g) Rock sampling during field trips. In the case of the UB, the vice-rector of Cultural Heritage (Vicerector d'Arts, Cultura i Patrimoni) has provided support for renting cars for visiting some important localities. The samples are collected in collaboration with the Barcelona SGA-SEG Student Chapter (see other communication in this volume; http://www.bcn-sga-seg.cat) and mineral collectors. More than 2000 samples have been collected.
h) Buying specimens from mineral dealers (in mineral fairs, mineral sale websites, etc.). More than 3000 samples have been obtained by this system. This is used for specimens of difficult access because of their relative rarity or value. This may be due to the scarcity of the mineral, as in case of native gold (fig. 9) or gem-quality crystals (fig. 10, 11).

Once the samples are collected and stored in the warehouse, the collections will be prepared following the next steps, carried out in collaboration with the Barcelona SGA-SEG Student Chapter:

a) Taking photographs of all the obtained samples. The receiving universities, as well as other universities willing to participate, could use these images to obtain a clear idea about the teaching qualities of the material. Moreover, these images can be helpful to these universities to understand the type of material that they could supply to the common warehouse.
b) Selecting and preparing the specimens needed for collection replica. Samples must have the required teaching quality and undesirable impurities will be eliminated.
c) Labelling the samples of the replicated collections. Samples may be labelled with the same codes used in the original collection of the UB to ensure that all the universities involved can use the same guidebooks.
d) Elaborating the corresponding guidebooks, including their corresponding translation if necessary.
e) Packaging and shipping the material.

At the moment, 6000 samples are stored and ready to be distributed.

Benefits of the project

a) To build an international network of universities hosting high quality material for the advanced teaching of Mineralogy based on the successful model of the UB.
b) To increase the level of training of the Geology students in Mineralogy in developing countries and therefore, reducing their external reliance.
c) To engage students and professors in an international collaboration.
d) To design a low-cost system for the universities to get valuable and useful material for

teaching.

e) To agree with research centres, mining companies and institutions a list with the essential minerals needed for the 21st century Geologists.
f) To establish factual bridges between the interest of the companies and the academic syllabus.
g) To make evident to companies and directives the importance of Mineralogy in the Geology studies.

At the present moment, the universities and centres that are involved in this project, apart from the University of Barcelona, are the universities of Zagreb (Croatia), Skopje (Macedonia), Agostinho Neto at Luanda (Angola), Dakar (Senegal), NTU (Singapore), Hyderabad (India), Nazarbayev University (Astana, Kazakhstan), UTECO (Universidad Tecnológica del Cibao Oriental, Dominican Republic), UNAM (Mexico), Recife and São Paulo (Brazil), Córdoba, Jujuy, La Plata, Salta, Catamarca (Argentina), and Universidad Católica del Perú (Peru). In addition, contacts have been stablished with other universities in New Zealand, Peru, Cuba, El Salvador and Chile. If this pilot project succeeds, we are thinking of asking for financial support from international agencies to increase the number of universities involved in the future.

Discussion on the preliminary results

The volume of the material obtained up to the present moment allows, not only restoring the original teaching capacities of the collections of Mineralogy of the University of Barcelona, but also increasing these capacities, by adapting them to the new demands of the industry. More than 6000 pieces of rocks representative of more than 250 minerals have been collected and stored (fig. 12). These samples cover an important proportion of the mineral species to be represented in the collections.

The main drawback for the teaching collections in Mineralogy is the high economic and time investment necessary to enhance the mineral collections. Every day, more than 100.000 mineral samples are sold on internet and, despite that this wide market gives a good opportunity to find some interesting samples at reasonable prices, it poses a problem when wanting to obtain large volumes of samples. Moreover, the number of mineral collectors increased during the recent years in many developing countries, meaning that many local sellers entered the globalised market. Therefore, the prices of the samples soar every month and certain types of pieces are close to disappearance from the market. This is the most important reason that impulses the cooperation between the participating universities. Typically, for a given university, gathering rock samples from nearby mineral deposits or districts is relatively easy; however, it is far more complicated to get material from mineral localities abroad. Therefore, we foresee this project as an opportunity to provide material from localities that would not be at their reach in other circumstances, without resigning from a complete teaching material that covers all important mineral species and localities worldwide, a key factor when teaching/learning Mineralogy.

One conclusion of this experience is that the teaching material for mineral demonstrations should ideally be obtained from localities that can provide, without any problem in the near future, a very large number of samples of similar quality of every listed mineral. Unfortunately, many of the classical localities are almost or completely exhausted, and therefore new alternative localities providing similar or better samples must be found in the middle-term future. The international collaboration between the involved universities is fundamental to overcome such a problem.

Moreover, the collaboration has activated other systems of direct exchange (both students and lecturers, often along with mining companies, are participating in field trips for collecting samples). Therefore, the project for cloning the mineral collections can be considered as a pilot project for other future collaborations in the field of the teaching innovation and in the effective collaboration between universities, and between these institutions and the industry.

Taking into account the cost of every mineral collection and the time used to prepare it, protocolary mechanisms such as agreements between universities are essential to ensure the effectivity of the project in the teaching improvement. It is necessary to create mechanisms of control to evaluate the benefits of the project in order to assess whether it is worth to increase the number of participating universities and to extend this experience to other subjects such as Petrology or Palaeontology.

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l'Or de Balaguer and the Bombers de la Generalitat. The project is a part of the regular activities of the BCN SGA-SEG Student Chapter, financed by the SGA and SEG societies.

5.1. FIGURA O IMATGE 1

Figure 1. General view of the hand samples of the teaching collections at the laboratories of the University of Barcelona.

5.2. FIGURA O IMATGE 2

Figure 2. Study of thin sections of mineral assemblages using transmitted and reflected optical microscopy at the laboratories of the University of Barcelona. Some samples are stored in the green plastic boxes at the back of the picture.

5.3. FIGURA O IMATGE 3

Figure 3. Single euhedral crystals of hornblende. These are selected to help the student to easily identify the three-dimensional shape of the crystals and to discover the shapes of the sections taken in different orientations. The samples are from Carboneras, Almería, Spain.

5.4. FIGURA O IMATGE 4

Figure 4. Hornblende crystals scattered within an andesite. These are selected to help the student identify shapes of the sections taken in different orientations within a rock. The samples are from Carboneras, Almería, Spain.

5.5. FIGURA O IMATGE 5

Figure 5. Euhedral crystals of stibnite from China. These are selected to show the ideal prismatic shape of the good-quality stibnite crystals.

5.6. FIGURA O IMATGE 6

Figure 6. Stibnite radial aggregates from China.

5.7. FIGURA O IMATGE 7

Figure 7. Massive cleavage columnar aggregates of stibnite from Alburquerque, Badajoz, Spain.

5.8. FIGURA O IMATGE 8

Figure 8. An example of the silver-rich samples from the Balcoll mine, near Falset, Catalonia. These were donated by Joan Abella, a Catalan collector and collaborator of the University.

5.9. FIGURA O IMATGE 9

Figure 9. An example of the gold-rich samples provided at low cost by the Canadian dealer Kerry Day. Gold occurs as small grains (hosted in quartz) whose size allow the identification at first glance.

5.10. FIGURA O IMATGE 10

Figure 10. Gem-quality spodumene crystals (pale pink variety kunzite) bought from an Afghan dealer. Samples are selected to show the typical shapes of a clinopyroxene crystal and to determine their typical sections (basal and longitudinal). These crystals are ready to be used for cloning.

5.11. FIGURA O IMATGE 11

Figure 11. Some of the gem-quality spodumene crystals (pale green variety hiddenite) bought from an Afghan dealer, ready to be used for replicating the collections. Samples are also selected to show the typical shapes of a clinopyroxene crystal, and determine their typical sections, basal and longitudinal.

5.12. FIGURA O IMATGE 12

Figure 12. Members of the Barcelona SGA-SEG Student Chapter at the warehouse of the Faculty of Earth Sciences of the University of Barcelona. Students prepare the collection replicas by selecting samples of: massive cleavaged white barite collected in situ from a Catalan locality with the help of a mining company (left); and hornblende-rich sections in andesite collected during a field trip of the Student Chapter to Cabo de Gata (Spain). The samples are stored in the wood boxes observed at the back of the image.

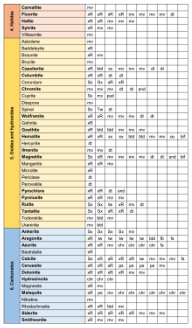
5.13. FIGURA O IMATGE 13

Table 1. Native elements, sulphides and sulphosalts. Sx, single crystal; xR, crystals within matrix; mv, fine-grained massive; mvc, massive cleavage; dt, disseminated; alt, altered; fs, fossils; ef, efflorescence; nod, nodule; pw, powdery; bw, burrow; btd, botryoidal; ng, nugget; bif, banded iron formation; oo, oolites; snd, sand; tw, twinned cystals; fb, fibrous; cr, crusts; ps, pseudomorphs,; asb, asbestiform

1. Native elements	Sulphur	xR	xR	mv							
	Bismuth	xR	mvc								
	Copper	xR	dt								
	Diamond	sx	sx	mv							
	Graphite	mvc	dt								
	Gold	dt	ng								
	Iron (meteoritic)	dt	mv								
	Silver	dt	dt								
	Platinum	ng									
2. Sulphides, arsenides, sulphide-arsenides	Acanthite	Sx	dt								
	Arsenopyrite	xR	xR	mv	mv	dt					
	Bismuthinite	mvc									
	Bornite	mv	mv								
	Chalcocite	mv	psd	fs	mv	mv					
	Chalcopyrite	xR	mv	mv	mv	dt, alt	dt				
	Carrollite	xR									
	Cinnabar	xR	dt	pw	mv						
	Cobaltite-Gersdorffite	mv									
	Covellite	mv	ps								
	Sphalerite	xR	xR	btd	mv	mv	mv	mv	mv		
	Stannite	dt									
	Stibnite	Sx	xR	mv	mv						
	Galena	xR	mn	mv	mv	mv	dt				
	Marcasite	xR	bw	mv	mv	mv					
	Millerite	xR									
	Molybdenite	mv	mv	mv							
	Nickeline	mv	mv								
	Orpiment	mv									
	Pentlandite	mv									
	Pyrite	Sx	Sx	xR	xR	mv alt	mv	mv	dt	dt alt	fs
	Pyrrhotite	mv	mv	mv	dt						
	Rammelsbergite-Safflorite	mv									
	Realgar	xR	mv								
	Skutterudite	xR	mv	mv							
	Sperrylite	xR									
	Valeriite	mv									
3. Sulphosalts	Boulangerite	mv									
	Bournonite	xR	xR	xR							
	Enargite	mv									
	Franckeite	mv									
	Jamesonite	mv									
	Proustite-Pyrargyrite	mv									
	Stephanite	mv									
	Tetraedrite-Tennantite	xR	mv	mv	dt	dt					
	Zinkenite	mv	mv								

5.14. FIGURA O IMATGE 14

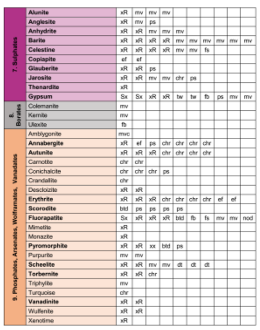
Table 2. Halides, oxides and carbonates. Legend as in Table 1.



4. Halides	Carnallite	mv									
	Fluorite	xR	xR	xR	xR	mv	mv	mv	mv	dt	
	Halite	xR	xR	mv	mv	mv					
	Sylvite	xR	mv	mv							
	Villiaumite	mv									
5. Oxides and hydroxides	Asbolane	mv									
	Baddeleyite	xR									
	Braunite	xR	mv								
	Brucite	mv									
	Cassiterite	xR	btd	xx	mv	mv	mv	dt	dt		
	Columbite	xR	xR	dt	dt						
	Corundum	Sx	Sx	xR	xR						
	Chromite	mv	mv	mv	dt	dt	snd				
	Cuprite	Sx	mv	psd							
	Diaspore	mv									
	Spinel	Sx	Tw	dt							
	Wolframite	xR	xR	mv	mv	mv	dt	dt			
	Gahnite	xR									
	Goethite	xR	btd	btd	mv	mv	mv				
	Hematite	xR	xR	xx	xx	btd	btd	mv	mv	oo	bif
	Hercynite	dt									
	Ilmenite	mv	mv	dt							
	Magnetite	Sx	xR	mv	mv	mv	mv	dt	dt	snd	bif
	Manganite	xR	xR	mv							
	Microlite	xR									
	Periclase	dt									
	Perovskite	dt									
	Pyrochlore	xR	xR	dt	snd						
	Pyrolusite	xR	xR	mv	mv						
	Rutile	Sx	Sx	tw	xR	mv	dt				
	Tantalite	Sx	Sx	xR	xR	dt					
	Todorokite	mv	btd	mv							
	Uraninite	mv	btd								
6. Carbonates	Ankerite	Sx	Sx	Sx	Sx	mv					
	Aragonite	xR	tw	tw	tw	tw	tw	btd	fb	fs	
	Azurite	xR	xR	mv	chr	chr	chr	chr	fs		
	Bastnäsite	xR									
	Calcite	Sx	xR	xR	xR	xR	tw	mv	mv	mv	fs
	Cerussite	xR	xR	xR	ps	ps	ps	ps	mv		
	Dolomite	xR	xR	xR	xR	mv	mv				
	Hydrozincite	chr	chr	chr							
	Magnesite	xR	mv								
	Malaquite	xR	ps	mv	chr	chr	chr	chr	chr	chr	chr
	Nitratine	mv									
	Rhodochrosite	xR	xR	btd	mv						
	Siderite	xR	xR	xR	xR	xR	mv	mv	mv		
	Smithsonite	xR	mv	mv	mv						

5.15. FIGURA O IMATGE 15

Table 3. Sulphates, borates, phosphates, arsenates, vanadates, wolframates. Legend as in Table 1.



7. Sulphates	Alunite	xR	mv	mv	mv						
	Anglesite	xR	mv	ps							
	Anhydrite	xR	xR	mv	mv	mv					
	Barite	xR	xR	xR	xR	mv	mv	mv	mv	mv	mv
	Celestine	xR	xR	xR	xR	mv	mv	fs			
	Copiapite	ef	ef								
	Glauberite	xR	xR	ps							
	Jarosite	xR	xR	mv	mv	chr	ps				
	Thenardite	xR									
	Gypsum	Sx	Sx	xR	xR	tw	tw	fb	ps	mv	mv
8. Borates	Colemanite	mv									
	Kernite	mv									
	Ulexite	fb									
9. Phosphates, Arsenates, Wolframates, Vanadates	Amblygonite	mvc									
	Annabergite	xR	ef	ps	chr	chr	chr	chr			
	Autunite	xR	xR	xR	chr	chr	chr	chr			
	Carnotite	chr	chr								
	Conichalcite	chr	chr	chr	ps						
	Crandallite	chr									
	Descloizite	xR	xR								
	Erythrite	xR	xR	xR	chr	chr	chr	chr	ef	ef	
	Scorodite	btd	ps	ps	ps	ps					
	Fluorapatite	Sx	xR	xR	xR	btd	fb	fs	mv	mv	nod
	Mimetite	xR									
	Monazite	xR									
	Pyromorphite	xR	xR	xx	btd	ps					
	Purpurite	mv	mv								
	Scheelite	xR	xR	mv	mv	dt	dt	dt			
	Torbernite	xR	xR	chr							
	Triphylite	mv									
	Turquoise	chr									
	Vanadinite	xR	xR								
	Wulfenite	xR	xR								
	Xenotime	xR									

5.16. FIGURA O IMATGE 16

Table 4.Tectosilicates, cyclosilicates, inosilicates. Legend as in Table 1.

10. Tectosilicates	Quartz	Sx	Sx	Sx	Sx	Sx	Sx	Mv	Mv	Mv	dt
	Chalcedony	btd	btd	nod	mv	mv	mv	mv	mv		
	Cristobalite	xR									
	Tridymite	xR									
	Opal	mv	mv	btd	fs	mv	mv	mv			
	Sanidine	xR	xR	xR							
	Orthoclase	xR	xR	xR	mvc	mvc	mvc	mvc	mvc	mvc	mvc
	Microcline	xR	xR	xR	mvc	mvc	mvc	mvc	mvc	mvc	mvc
	Adularia	xR	xR	xR	xR						
	Plagioclase	tw	mvc	mvc	mvc	mvc	mvc	mvc	mvc		
	Albite	tw	mvc	mvc	mvc	mvc	mvc	mvc	mvc		
	Anorthoclase	mvc									
	Meionite-Marialite	Sx	xR	xR							
	Nepheline	xR	xR	mv	mv						
	Leucite	xR	xR	xR	xR	xR					
	Sodalite	xR	xR	mvc							
	Hauyne	xR	xR								
	Cancrinite	mv									
	Analcime	xR	xR	ps							
	Chabazite	xR	xR								
	Clinoptilolite	mv	mv								
	Stilbite	xR	xR								
	Heulandite	xR	xR	mv							
	Mordenite	mv									
11. Ring silicates	Beryl	Sx	xR								
	Cordierite	xR	xR	xR	xR	xR	xR				
	Schorl	Sx	Sx	xR	xR	xR	xR	dt			
	Dravite	Sx	xR								
	Elbaite	Sx	xR	xR	xR						
	Eudyalite	mv									
12. Inosilicates	Enstatite	mvc									
	Diopside	xR	mvc	mvc							
	Hedenbergite	xR	xR	mvc	mvc	mvc					
	Chromian diopside	xR	mvc								
	Augite	Sx	Sx	Sx	Tw	xR	xR	xR			
	Aegirine	xR	xR	fb							
	Spodumene	Sx	mvc	xR							
	Jadeite	mvc									
	Omphacite	mvc									
	Pigeonite	xR									
	Wollastonite	xR	fb	fb	fb						
	Rhodonite	mv	mv								
	Antophyllite	mvc									
	Grunerite	mvc									
	Tremolite	xR	xR	fb	asb						
	Actinolite	xR	xR	xR	fb	asb	ps				
	Hornblende	Sx	Sx	xR	xR	xR	xR				
	Arfvedsonite	mvc									
	Glaucophane	mvc	mvc								
	Kaersutite	xR									
	Riebeckite	xR	xR								

5.17. FIGURA O IMATGE 17

Table 5. Phyllosilicates, sorosilicates, nesosilicates. Legend as in Table 1.

13. Phyllosilicates	**Kaolinite**	mv	mv	ps							
	Antigorite	mv	mv	mv							
	Chrysotile	fib	fib	fib	fib						
	Lizardite	mv									
	Pyrophyllite	mvc									
	Talc	mv	mv	mv							
	Nickelian talc	btd									
	Biotite	Sx	xR	xR							
	Phlogopite	mvc									
	Moscovite	Sx	xR	mvc	mvc	mvc	mvc	mvc	mvc	mvc	
	Glauconite	nod									
	Illite	mv									
	Lepidolite	Sx	mvc	mvc	mvc						
	Montmorillonite	mv									
	Vermiculite	xR									
	Chamosite	mv									
	Clinochlore	xR	mvc	mvc	mvc	mvc	ps	ps			
	Prehnite	xR	xR	xR	xR						
14. Sorosilicates	Axinite	xR									
	Epidote	xR	xR	xR	xR	xR	mv	mv	ps	ps	
	Zoisite	mv									
	Clinozoisite	mv									
	Piemontite	mvc									
	Allanite	mv									
	Vesuvianite	Sx	xR	xR	xR	xR	xR	mv			
	Pumpellyite	xR									
	Melilite	xR									
	Hemimorphite	xR	xR								
15. Nesosilicates	**Forsterite**	Sx	Sx	xR	xR	xR	mv	mv			
	Monticellite	mv									
	Humite	dt									
	Andalusite	Sx	Sx	xR	xR	xR	xR	dt	dt	dt	dt
	Sillimanite	fib	fib								
	Kyanite	Sx	xR	xR	xR	mvc	mvc				
	Pyrope	xR	xR	xR							
	Spessartine	xR									
	Almandine	Sx	xR	xR	xR	xR	xR	dt	dt	dt	snd
	Grossular	Sx	xR	xR	xR	xR	xR	xR	mv		
	Andradite	Sx	xR	xR	xR	xR					
	Uvarovite	xR									
	Zircon	Sx	xR	xR	snd						
	Titanite	xR									
	Topaz	Sx	Sx	xR	xR						
	Chloritoid	xR	xR								
	Staurolite	Sx	Sx	Tw	Tw	xR	xR	xR	xR		

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6. REFERÈNCIES BIBLIOGRÀFIQUES (segons normativa APA)

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