



Electron Microscopy in Latin America

Alwyn Eades

There are many countries in Latin America and huge differences between them. So I must have been slightly crazy to propose writing an article on electron microscopy in Latin America. Just as it would be unwise to write on the cuisine of Europe with an implicit assumption that it is all the same, so this may be an unwise enterprise that will lead people to imagine that there is homogeneity across a hugely diverse continent. Despite the diversity, as far as electron microscopy is concerned it will be convenient to group the countries. In the first group are Brazil, Mexico and Venezuela. These are the countries in which microscopy is well developed. The next group includes Chile, Costa Rica, Argentina, Cuba (although, as always, Cuba is one of a kind) and perhaps Peru, Ecuador and Colombia. In these countries electron microscopy is carried out by a small number of people. To the best of my knowledge, there is no electron microscopy worthy of the name in the remaining countries and they form the third group.

The bulk of this article will discuss, in some detail, the situation in two of the countries of the middle group. First, however, I would like to say something about the regional organization for electron microscopy and how I come to be in a position to write this article. Just as there are national electron microscopy societies in the countries of Europe, but there is also the European Microscopy Society, which acts as an umbrella society for all of Europe and which is a regional organization for the International Federation of Societies for Microscopy, so the countries of the Americas have (in many cases) national societies but there is also a regional organization.

The regional organization for the Americas is called CIASEM, The InterAmerican Committee of

Societies for Electron Microscopy, or Comité Interamericano De Sociedades De Microscopía Electrónica (nobody seemed to notice that the acronym does not work in either language). For the period 2004 to 2005, I was president of CIASEM and used part of a sabbatical in the Spring of 2005 to visit Costa Rica, Ecuador and Chile. I have also made professional visits to Cuba, Venezuela, and Mexico quite recently and visited Brazil not too long ago. The most important activity of CIASEM is the organization of the InterAmerican Congress of Electron Microscopy which is held every two years (in odd years). The most recent meeting was in Havana in 2005. The next one will be in Cuzco, Peru from 23 to 28 September, 2007. Further details regarding CIASEM and the Ninth InterAmerican Congress can be found at the CIASEM web site: www.ciasem.com.

The Major Players

Brazil is the most advanced. There are many universities and research centres with electron microscopes and well trained people who use them. The work they do is at an advanced level. The scale of things can be judged by the fact that their national society is well established, successful and strong. They hold annual meetings that attract several hundred attendees and at which the work presented, though variable in quality, has much that

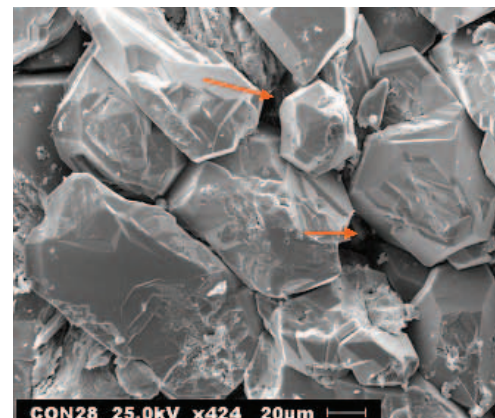


Fig. 1. Fine grained sandstone showing good packing of the grains as well as intergranular voids. Mineralogical study from the Center for Geological Research, PetroEcuador, Guayaquil, Ecuador.

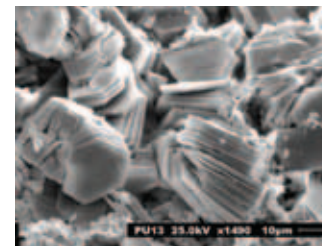


Fig. 2. Crystals of kaolinite clay grouped in blocks with microporosity. Sample from a depth of ten thousand feet. Courtesy of PetroEcuador.

is first rate. Mexico and Venezuela also both have several centres of electron microscopy that are stable, successful and above critical mass. They also both have well established microscopy societies that hold well attended annual meetings, though not as large as those in Brazil. Over many years, these two countries have seemed to me to be on a par. However, recently there has been an expansion in Mexico. They have recently purchased several advanced microscopes and are developing microscopy in several provincial universities where investments on this scale were not previously possible. On the other hand, in Venezuela, things seem, in recent years, to have stagnated to some extent.

Costa Rica

Costa Rica is amazing. You probably know that Costa Rica has no armed forces and that fully a quarter of its area is given over to national parks and other protected areas. You probably don't know that Costa Rica is also amazing for its electron microscopy. Almost anonymously Costa Rica has a centre for electron microscopy on a par with centres in the United States or Europe.

El Centro de Investigación en Estructuras Microscópicas, CIEMIC (The Centre for Microstructural Research) has its own purpose-built building with an infrastructure that would make most of us envious. The four microscope rooms have independent concrete slabs for vibration-free mounting of the microscopes. The whole building has an emergency generator system to protect the equipment from power failures. There are about twenty rooms for sample

preparation and related work as well as the darkrooms and offices. Since much of the research in the Centre is related to analysis of delicate biological samples, temperature control is strict, instruments track and record the history of each sample including its temperature at all times. Critical equipment is duplicated so that tissue processing is not interrupted by instrument down time. Quality control and inspection of the quality control measures are maintained to the levels expected for the most demanding work of the National Institutes of Health (of the USA), for example.

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CIEMIC was founded in 1974 with support from the Japanese government. JICA (Japan International Cooperation Agency), the organization that created the Centre, is to be congratulated on a job done extraordinarily well. For more than twenty years, the Centre acted mostly as a centre for teaching electron microscopy. Each year JICA funded a six-month course to train microscopists from all of Latin America. As a result many electron microscopists in the biological sciences across the Americas were trained in Costa Rica. In 1997, JICA ended its support for CIEMIC and everything changed.



Fig.3. Centro de Investigación en Estructuras Microscópicas, CIEMIC (The Center for Microstructural Research), in the University of Costa Rica.

CIEMIC has reinvented itself as a centre for research – and has done so with great success. The Centre now publishes twenty or more publications each year in international journals. The infrastructure is supported from the budget of the University of Costa Rica, in which the Centre is located, but the funding for the research itself comes from grants. Grants are sought within Costa Rica, within the region, and internationally. This research funding from grants currently runs at about US\$1 million per year.

The Centre has four electron microscopes: two transmission electron microscopes (Hitachi H-7100 and Hitachi H-7000) and two scanning electron microscopes (Hitachi S-2360N and Hitachi S-570). A confocal microscope will be purchased shortly. The instruments are not new. The most recent acquisition is now about 15 years old, but they are well maintained and are in very good condition. The original focus on biological applications is being broadened to extend to materials sciences too. As a part of this effort, EDS systems for chemical analysis have recently been added to one of the TEMs and to one of the SEMs.

The main research activities are, as might be expected, related to the environment and economy of Costa Rica. Immunology and virology, both in the context of human health and in the context of

agricultural problems, are leading fields. There is a program of research on red tides, which affect Costa Rica as they do many other coastal regions.

This may seem like paradise but there are problems. A recent change in the law regarding professorial pensions had the effect of causing a large fraction of the researchers working with the microscopes to retire in 2003. It will take some time to rebuild the strength of the research team. One result of this is that now is a particularly good time for the development of collaboration with CIEMIC. They have always wanted to strengthen collaboration but this is an especially favorable time. The other problem is that the microscopes

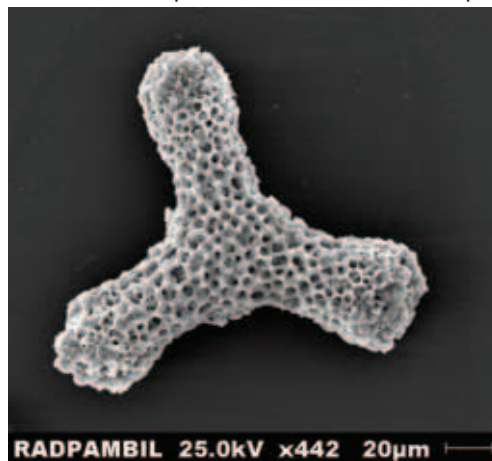


Fig.4. *Rhopalodictyum* sp. Late Oligocene. SEM image of microfossil (found at Cuenca Borbón) from the Center for Geological Research in the labs of Petroecuador, the national petroleum company in Guayaquil Ecuador.

The present situation in Ecuador is not a happy one. There are seven electron microscopes in the country and all of them are in working order, so why then are things not good?

will not last for ever and there is concern at the difficulty of getting the next instrument. Anyone who is interested in more information should contact the Director of the Centre, Enrique Freer, at efreer@cariari.ucr.ac.cr.

Costa Rica is a small country but one that gives the impression of doing things right. Whether it was planning in this case, or the accidental result of gifts from Japan, Costa Rica does very well because microscopy is centralized. All their electron microscopy is in one place and therefore there is - at that one place - a critical mass that keeps good work flowing. Costa Rica does not have a microscopy society. They do not feel a need for one. All of the people who do electron microscopy do it in the same building. This is a real contrast with Ecuador which, unfortunately, ends up at the other extreme.

Ecuador

The present situation in Ecuador is not a happy one. You would think that this ought not to be the case. There are seven electron microscopes in the country and all of them are in working order (although with problems – see below), so why then are things not good? The problem begins with geography. Unlike most small countries, Ecuador is not dominated by a single large city. There are two major cities, locked in a continuous rivalry: Quito, the capital, is in the mountains, and Guayaquil, the larger city, is on the coast. They are about seven hours apart by road. Both cities have electron microscopes. Worse, however, is the fact that, in each city, the microscopes are in two different locations – making a total of four microscopy centres. This is too many and Ecuador can not support them all effectively.



Fig. 5. Fernando Ponce of Arizona State University lecturing to students from across the Americas at the Pan-American Advanced Studies Institute on Transmission Electron Microscopy in Materials Science, in Santiago, Chile in July 2006.



Fig.6. Alwyn Eades of Lehigh University (extreme right) in a discussion with students at the Pan-American Advanced Studies Institute on Transmission Electron Microscopy in Materials Science. Santiago, Chile, July 2006.

The most effective centre is in the National Institute for Hygiene and Tropical Medicine, in Guayaquil. They have four microscopes: two SEMs - a JEOL 5310 and a Hitachi S 430 - and two TEMs, a JEOL 1010 and a JEOL 100C. The older instruments are used only for teaching while the newer instruments are used mostly for pathology and other relatively routine analyses. Despite this apparent strength, there are only three active users of these instruments. It is not enough to secure long-term stable operation.

The other centre in Guayaquil is in the Centre for Geological Research in the labs of Petroecuador, the national petroleum company. They have a Philips 515 SEM (with EDS) that has been regularly and frequently used for the analysis of geological samples related to oil exploration, as well as a lot of work on microfossils.

The two labs in the Quito area are in worse shape. The Social Security Hospital has a TEM - a JEOL 100CX. But, since its sole user has been promoted to a senior administrative post, it had not been

used for a year when I visited. In the Polytechnic University of the Army (in Sangolquí, just outside Quito), there is a Zeiss 960A SEM (with EDS). It was abandoned for a time but is being brought back into operation. It does not yet have a user base, although there are signs that the administration is taking steps to make good use of this instrument.

What these centres have in common is a lack of infrastructure. Two of the most important instruments had problems during my visit (the JEOL 5310 and the Philips 515) and the resources for fixing them are inadequate. At all of the centres, there is a lack of qualified users. As in the case of the hospital in Quito, all of the centres would be vulnerable to complete collapse if one or two people were to leave or get promoted.

Overall then the problem is one of resources spread too thinly. The activity in Ecuador could support one centre for electron microscopy but can not support four. However, for geographical and political reasons, four is what they have. This

makes it all the more important that the four centres collaborate as much as they can. It would be very helpful if the people involved in the four centres were to meet on a regular basis and work together to develop their collective strength. For there to be a successful future for electron microscopy in Ecuador, I think that the four centres would need to think of themselves as part of a single group. Unfortunately, there was not much sign of this during my visit. The national microscopy society is largely defunct and the microscopists at the different laboratories do not interact very much.

Other Countries

Cuba, as might be expected, controls more closely the way things are run than other countries. There is a modest level of electron microscopy in the country and a national society. However, microscopy is directed at very specific programs. In particular, Cuba is strong in areas related to medicine and to pharmaceuticals but quite weak in the application of microscopy to physical sciences. In the areas that are supported, the resources and infrastructure are good.

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Chile and Argentina have both had active research groups using electron microscopy since the 1960's. Chile is the case I know best. In Chile there are several centres of electron microscopy, at least six of them. Most of them emphasize scanning electron microscopy, and most of them focus on the research in the university where they are housed, although two of them are very successful in running work for industry too. Doing work for industry, within Latin America, in general is not easy. Most industry still works to recipes from the developed world and has little interest in solving its own problems.

Transmission electron microscopy has been less successful of late because there had been no new



Fig.7. Erwan Sourty of FEI operating the new field-emission transmission electron microscope at the University of Chile.



Fig.8. Francisco Brieva, Dean of the Engineering College at the University of Chile, being introduced to the new field-emission electron microscope. The microscope is being operated by Erwan Soury of FEI. In the background (left to right) are Fernando Lund director of CIMAT (Centro Para La Investigación Interdisciplinaria Avanzada En Ciencias De Los Materiales), Alwyn Eades (Lehigh University) and Diego Morata (Universidad de Chile).

instruments purchased for a while. There is reason to hope for a change here. A new field-emission TEM was recently delivered to the University of



Fig.9. Phacodiscus sp. Late Oligocene. SEM image of microfossil (found at Cuenca Borbón) from the Center for Geological Research in the labs of Petroecuador.

Chile as a part of a joint rejuvenation program for materials science. This program involves a collaboration between the three major universities in the country. The new microscope was the focal point of a recent workshop: The Pan-American Advanced Studies Institute on Transmission

Electron Microscopy of Materials. This workshop (funded by the National Science Foundation and the Department of Energy of the United States) brought together young microscopists from across Latin America for two weeks during which they were given advanced training in TEM.

In Argentina, there are a total of about thirty laboratories active in electron microscopy, most of them based on scanning electron microscopy. The majority are in universities and research institutes but some are in industrial labs. Three laboratories stand out as strong in transmission electron microscopy. Two focus on materials (in Bariloche and in Buenos Aires) and one on biomedical applications (in Mendoza). These three centres have well established research groups and the level of research is high.

In both Chile and Argentina, microscopy societies, which were once active, had become defunct, but are now being reactivated. I believe that this is

important for the future of microscopy at the southern end of the continent.

Things look good for Chile and Argentina but for Peru and Colombia the situation is not so good, I fear. Although I have not visited recently, I suspect that they face a situation more like that of Ecuador, than like the other countries I have mentioned here.



Fig.10. Globigerina ciperoensis. Early Miocene. SEM image of microfossil (found at Cuenca Borbón) from the Center for Geological Research in the labs of Petroecuador.

Summary

There is a broad spectrum of activity in electron microscopy in Latin America. From Brazil which has a breadth and depth of activity that would put it on a par (for example) with a country in Europe, to those countries (which I have not named) in which there are no instruments and no microscopists. Some sense of how things stand can be gauged from the fact that in addition to the field emission TEM in Chile (mentioned above), Mexico has four field-emission transmission electron microscopes (and two more on order). One has aberration correction, as does one of those on order. Two of the instruments are in centres outside Mexico City (Morelia and San Luis Potosi). Brazil is on the point of installing three field-

emission transmission electron microscopes, including an aberration-corrected TEM.

Despite the good things, all electron microscopists in Latin America suffer from limited resources and from some measure of marginalization from the mainstream of science. Therefore, if you do get the chance, let me recommend that you do what you can to help our colleagues in that part of the world. You could start by attending the InterAmerican Congress on Electron Microscopy in Cusco, next September. If you have always wanted to visit Machu Picchu - this could be your chance.

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Alwyn Eades, a professor of materials science, has worked in electron microscopy throughout a long career. His

interests relate mostly to developing new techniques and finding ways to enhance the performance of the microscope. Much of his work has centered on diffraction in both transmission and scanning electron microscopy. Early in his career he worked in Chile and has had a continuing interest in Latin America ever since.