NANOMETRIC INCLUSIONS IN MINERALS. AN EPMA, TEM/SAED AND MÖSSBAUER (NGR) APPROACH

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A large number of mineral species (some 4-500 of about 4,000 known today) commonly occur as inclusions in other minerals and their identification needs as a rule more sophisticated equipment. Mineral species, which are known to occur only as inclusions are called **micro-minerals**, *i.e.* micrometer-sized bodies, such as mackinawite in pentlandite or in polyphase chalcopyrite-dominated inclusions in sphalerite. Careful microscopic investigation is commonly sufficient for identification, provided the optical properties are different as compared to the host minerals. Further examples: ulvöspinel in magnetite, sometimes valleriite in pentlandite, isocubanite (the former "chalcopyrrhotite") in chalcopyrite inclusions in sphalerite *etc*.

There are also cases when the microscope cannot help further in establishing the true nature of sub-micrometer inclusions. In such cases EPMA should be used coupled with microdiffraction devices. Examples can be given of numerous mineral species or compound found in the arsenopyrite from the Costesti gold ores, South Carpatians, Romania. Only by using EPMA sub-micrometer sized gold, a schreibersite-like phase (with Fe > Ni), greenockite and several Bi-containing phases have been determined (see UDUBAŞA, 2004, for details). Such inclusions could be called "**infra-minerals**".

A third level of inclusions can be traced at nano-size, *i.e.* microscopically impossible to be seen and hardly difficult to be hit. In such cases TEM/SAED seems to be the only way to recover the nano-world of minerals ("**nano-minerals**"). Two examples can by here given: (1) Discovery of wüstite and pyroxferroite as nanoinclusions in manganoan fayalite at Răzoare, Preluca Mts., Romania (CONSTANTINESCU *et al.*, 2004). These two minerals mark a very early, high PT mineral association during the metamorphic evolution of the rock pile. (2) Identification of nanometer-sized inclusions or "precipitates" of gold in or on arsenopyrite, pyrite and chalcopyrite from some shear-zone related ores in metamorphic rocks of the South Carpathians (for further details see UDUBAŞA S. S. *et al.*, 2006, abstract in this volume). The first level is represented by optically visible gold inclusions (most frequently seen in arsenopyrite). The second level has been established by extensive use of EPMA: around gold inclusions in arsenopyrite there were measured decreasing gold contents in apparently homogeneous parts of arsenopyrite monocrystals (UDUBAŞA & TOPA, 1995; UDUBAŞA, 2004). This is the so-called invisible gold in sulphides. The third level of gold occurrence is only possibly to visualize by using TEM/SAED techniques. In addition to gold, a further "nano-mineral" in pyrite from the Costeşti gold ores is the rare Ag-Au sulphide, uytenbogaardtite.

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References

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