# Contribution to the study of the petrogenesis of granitic pegmatites; the example of the LCT pegmatites of Elba Island (Tyrrhenian Sea, Italy).

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***Introduction*** - The Elba granitic pegmatites (Tyrrhenian Sea, Italy) form an LCT pegmatitic field along the eastern border of the Tertiary Mt. Capanne monzogranitic pluton. Such dikes are of particular interest for the study of the petrogenesis of granitic pegmatites since, at a small scale, they contain much of the characteristics typical of many other important pegmatitic districts around the world. Indeed Elba pegmatites present a variety of inner structures, different hosting rocks, complex and rich mineralogy (Orlandi & Pezzotta 1996), and a wide range of the degree of geochemical evolution. The author, performing field and laboratory studies, and occasionally participating in the last two decades to small scale mining, collected a large quantity of data, documenting in three dimensions the structural and mineralogical characteristics of many dikes.

***Previous information*** - Internal structures and parageneses of the Elba pegmatites have been described in Pezzotta (2000). In such work, Elba pegmatites are classified into 4 categories based on internal structures and on the mineralogy: Cat.-1) Dikes without Li minerals; Cat.-2) Li-bearing dikes with complex asymmetric zoning; Cat.-3) Li-bearing dikes with simple asymmetric zoning; cat.-4) Irregularly zoned to unzoned Li-bearing dikes. The degree of geochemical fractionation increases from Cat.-1 to Cat.-4. The less geochemically evolved dikes of Cat.-1 are mostly emplaced inside the granitoids of the pluton, and the most evolved ones of Cat.-4 are all emplaced in the thermometamorphic rocks (metasediments and metaserpentinites) of the contact aureole.

Ruggeri & Lattanzi (1992), studying fluid inclusions in vug crystals of quartz, tourmaline-group minerals, and beryl, calculated the upper pressure limit for pegmatitic crystallization at ≈ 2 Kbar.

The Mt. Capanne intrusion is a composite pluton fed by multiple anatectic hybrid melt batches that experienced further mixing at the emplacement level (Dini et al., 2004). The eastern portion of the pluton, corresponding to the area of occurrence of the LCT pegmatitic field, is characterized by fine to medium-grained monzogranite, described in Dini et al. (2002) as the "San Piero facies". Significant masses of leucogranite and aplite, with sienogranitic composition, occur within both the monzogranite of the San Piero facies and the metamorphites of the contact aureole. Dini et al. (2002), on the basis of major and trace elements modeling and Sr-Nd isotopic data, interpreted the leucogranites as fractionation products from a magma having geochemical characteristics similar to those of the San Piero facies.

***Selected new data*** - Recent researches evidenced the following information:

- Many leucogranitic lenses (with ± cordierite and ± schorl), occurring within both the monzogranite and the metamorphites of the contact aureole, contain lenses and pods of miarolitic, high-evolved, LCT pegmatites ("Catri Type", Cat.-3), very likely indicating that the hosting leucogranite represents the direct parent magma.
- LCT pegmatites hosted in monzogranite (Cat.-2 and Cat.-3), and pegmatites hosted in contact metamorphites (Cat.-4), are in strict spatial relation with the masses of leucogranite.
- Structural evidences indicate that monzogranite was not yet totally crystallized at the moment of pegmatite emplacement.
- Structural and petrographic data at the outcrop-scale and at the micro-scale evidences in some pegmatitic dikes significant processes of monzogranite assimilation.

- Complex histories of crystallization at the magmatic stage are documented by multiple pegmatite intrusions, pegmatite and aplite brecciation, and magmatic slumping in “line rock”.
- Typical “line rock” characterizes pegmatites hosted both in monzogranite and leucogranite dikes, and in metaserpentinite.
- Geochemically highly evolved mineral assemblages (elbaite, petalite, pollucite, Li-micas, etc.) can be present in very small portions of rather primitive pegmatitic dikes (Cat.-2), representing the latest stages of crystallization of the dikes. The highly evolved pegmatites (Cat.-3 and Cat.-4) achieved the crystallization of highly evolved mineral assemblages since the first stages of magmatic crystallization.
- In Elba pegmatites, crystals of magmatic tourmaline-group minerals, grew systematically in the direction of the analogous pole. This direction of growth is constant both in crystals forming “comb” textures and in crystals forming graphic aggregates with quartz.
- In some relatively primitive pegmatites of Cat.-2, quartz-tourmaline, quartz-K-feldspar, quartz-albite, and quartz-spessartine graphic aggregates crystallize up to the pocket formation.

***Petrogenetic inferences*** – Most recent data indicate that Elba pegmatites seems to be genetically strictly related to leucogranitic masses (with ± cordierite and ± schorl). Depending also on the results of the first geochemical investigations (Dini et al. 2002), such granitic rocks could represent an intermediate product between the monzogranite of the “San Piero facies”, and the LCT granitic pegmatites.

In view of the many different phenomena observed which characterize granitic pegmatites, and in view of the recent model for pegmatite crystallization proposed by London (2005), which considers a process of *constitutional zone refining* (CZR) generating *fluxed boundary layers* (FBL), I propose to approach the study of the petrogenesis of granitic pegmatites considering pegmatitic pods, veins, dikes and stocks as particular cases of small-scale *magma chambers*, in which the main mechanism controlling crystallization is the process of CZR. On Elba, pegmatitic masses from centimeter to several decimeters across experienced after emplacement a complex crystallization history involving:

- host-rock (monzogranite) assimilation, resulting in magma contamination;
- multiple intrusions, with various degrees of magma mixing;
- magma differentiation, generating geochemically primitive to high evolved mineral assemblages;
- instability of the “magma chamber”, resulting in auto-intrusions, late highly-evolved liquid eruptions, magmatic slumping;
- “closed system fluid circulation”, generated by the exsolutions of syngenetic fluids;
- post-magmatic “open system fluids circulation”, due to the presence of external fluids.

The process of CZR, producing a flux-rich boundary layer (in which incompatible elements are concentrated acting as fluxes to lower the solidus of the melt) able to advance into a solid or semisolid body ahead of the crystal growth front (London 2005), could explain how pegmatitic liquids can be so aggressive to a monzogranitic host rock with a temperature close to its solidus (such as on Elba island).

This study indicates also that great differences in the degree of undercooling of pegmatitic liquids at the moment of emplacement can exist in dikes belonging to the same pegmatitic field. This is particularly evident in Elba comparing dikes emplaced in partially solidified monzogranite (or syngenetic dikes in leucogranite), with dikes hosted in metamorphites of the contact aureole. These pegmatites probably experienced also significantly different cooling histories.

For a better interpretation of the pegmatite zoning, the concept of *pegmatitic macrostructure* (PM) is here proposed, with “PM” defined as the complex of the rock-structures and the intrusive-body-zones developed under a homogeneous geochemical differentiation event. Single PM can constitute whole pegmatitic dikes, limited portions of dikes mainly characterized by homogeneous, fine to medium grained rock, or portions of dikes composed by multiple PM. A main feature of a PM is that crystals of minerals forming solid solutions (e.g. tourmaline-group) experienced the same history of crystallization during growth and the same geochemical evolution of the silicatic liquid and of the fluid phase. Late-stage circulation of pegmatitic syngenetic fluids participate in the development of a PM (alterations, replacement units). Open system circulation of external fluids is a local event which is superimposed onto a PM.

● Dini A., Innocenti F., Rocchi S., Tonarini S., Westerman D.S. (2002) The magmatic evolution of the late Miocene laccolith-pluton-dike granitic complex of Elba Island, Italy. Geological Magazine 139 (3), 257-279.● Dini A., Rocchi S., Westerman D.S. (2004) Reaction microtextures of REE-Y-Th-U accessory minerals in the Monte Capanne pluton (Elba Island, Italy): a possible indicator of hybridization processes. Lithos, in press. ● London D. (2005) Granitic pegmatites: an assessment of current concepts and directions for the future. Lithos, 80, 281-303. ● Orlandi P., Pezzotta F. (1996) Minerali dell'Isola d'Elba, i minerali dei giacimenti metalliferi dell'Elba orientale e delle pegmatiti del M.te Capanne. Ed. Novecento Grafico, Bergamo. 248 pp. ● Pezzotta F. (2000) Internal structures, parageneses and classification of the mirolitic Li-bearing complex pegmatites of Elba Island (Italy). Mem. Della Società Italiana di Scienze Naturali e del MSNM., XXX, 29-43. ● Ruggeri G., Lattanzi L. (1992) Fluid inclusion studies on Mt. Capanne pegmatites, Isola d'Elba, Tuscany, Italy. European Journal of Mineralogy 4, 1085-1096.