# A LOOK AT PEGMATITE CLASSIFICATIONS

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Modern pegmatite classification schemes are strongly influenced by the depth-zone classification of granitic rocks published by Buddington (1959), and the Ginsburg et al. (1979) classification which categorized pegmatites according to their depth of emplacement and relationship to metamorphism and granitic plutons. Černý's (1991) revision of that classification scheme (Table 1) is the most widely used classification of pegmatites today. His classification is a combination of depth of emplacement, metamorphic grade and minor element content. His 1991 classification has 4 main categories or Classes. These are **Abyssal** (high grade, high to low pressure), **Muscovite** (high pressure, lower temperature), **Rare-Element** (low temperature and pressure), and **Miarolitic** (shallow level). The Rare-Element Classes are subdivided based on composition into **LCT** and **NYF** types: **LCT** for **L**ithium, **C**esium, and **T**antalum enrichment and **NYF** for **N**iobium, **Y**ttrium, and **F**luorine enrichment. The Rare-Element Class is further subdivided into types and subtypes according to the mineralogical / geochemical characteristics as shown in Table 2. This scheme has been used in most modern pegmatite studies.

Many pegmatites fall nicely into these categories, but during the last decade various investigations have revealed pegmatites that don't fit into these categories. Most notably pegmatites of the NYF affiliation have required a more detailed classification as more studies revealed a greater diversity of NYF-type pegmatites. One problem is the classification of some pegmatites as NYF that contain little or no yttrium or others that contain little or no niobium. Many pegmatites from Madagascar described by Pezzotta that are hyper-enriched in Cs don't fall into these categories. Additionally, a number of pegmatites show "mixed NYF and LCT characteristic and these are not addressed in the classification. Moreover attempts to relate pegmatite types or subtypes to magma genesis or tectonic regimes as has been attempted in granite classifications are not satisfactory (Simmons et al. 2003). Also, Černý's 1991 classification fails to address the possibility of pegmatites forming by direct anatexis. Consequently, over the last few years several new modifications of Černý's classification have been proposed. A few selected examples that illustrate the direction that classifications are evolving are presented below.

A basic classification for pegmatites of Madagascar (Table 3), based in part on Černý's 1991 classification, was introduced by Pezzotta (2001). This classification retains much of the nomenclature and framework of the older depth-related classification schemes, but is modified by pegmatite mineralogy which relates to pegmatite bulk chemistry. New types and subtypes were introduced that better represent the compositions of some of the Madagascan pegmatites that are virtually unique. Pezzotta's Class I, the Abyssal Class, applies to pegmatites found at low to high pressure and the highest temperatures. Generally, these pegmatites are poorly mineralized but may contain ceramic materials to make them economically important. Class II, the Rare Element Class, is the most mineralized and most mineralogically diverse. It is subdivided on the basis of a characteristic mineral assemblage for the pegmatite. In some cases, a distinction as to NYF and LCT types is specified. Class III, the NYF Miarolitic Class, is based on a low pressure regime. These pegmatites are rich in miarolitic cavities and typically occur at relatively shallow depth.

Wise (1999) introduced a new expanded classification of NYF pegmatites (Table 4). His classification relates pegmatites with NYF geochemistry to A-type granite plutons. He related these pegmatites to post-tectonic to anorogenic plutons formed in continental or oceanic rift zones. His classification has three main categories based on aluminum saturation of the parent granite. The three groups are peralkaline, metaluminous, and peraluminous. Within each group, pegmatite types are distinguished by mineralogical and geochemical characteristics. This classification is comprised of 6 types and 9 subtypes (Table 4). His classification relates NYF pegmatite mineralogy to variations in the alkalinity of the parental granitic melts.

Zagorsky, Makagon & Shmakin (1999) proposed a new classification based on pressure, pegmatite formation, geochemical / mineralogical sequences, and structural types (Table 5). A point emphasized in this scheme is the observation that miarolitic cavities can occur in all 3 of their types. They propose the idea of a miarolitic facies which can occur in a greater or lesser degree in almost any pegmatite sequence.

In examining more than 500 pegmatite descriptions, Ercit (2004) found a low degree of correlation between accessory mineralogy and depth of emplacement for NYF pegmatites (Table 6). Building on the Wise classification, he proposed that NYF pegmatites belong to the Abyssal, Muscovite-rare-element class, as well as the Rare-element and Miarolitic classes. He also subdivided the abyssal class into two subdivisions: the allanite-monazite-uraninite subtype and the (Y, REE)-Nb-oxide subtype. In the rare element class, the rare earth fluorine type is defined and subdivided into three subdivisions based on HREE vs. LREE and mineralogy: allanite-monazite, euxenite, and gadolinite subtypes (Table 7).

A new classification scheme by Černý and Ercit (2005) has just been proposed at the GAC/MAC meeting in Halifax, Canada last week and is in press. This scheme combines the Černý 1991 and Ercit 2004 classifications (Tables 8 and 9) and introduces a new petrogenetic classification (Table 10) in which three families are distinguished: “an NYF family with progressive accumulation of Nb, Y and F (besides Be, REE, Sc, Ti, Zr, Th and U), fractionated from subaluminous to metaluminous A- and I-granites that are generated by a variety of processes involving depleted crust and/or mantle contribution; a peraluminous LCT family marked by prominent accumulation of Li, Cs and Ta (besides Rb, Be, Sn, B, P and F) derived mainly from S-granites, less commonly from I-granites; and a mixed NYF + LCT family of diverse origins (e.g., NYF plutons contaminated by digestion of undepleted supracrustals)”.

New also (GAC/MAC 2005) is the proposal by Martin & De Vito (2005) which contends that the depth-zone classification cannot account for the two main geochemical categories of pegmatites: LCT and NYF. They propose that the tectonic setting determines the nature of the parent magma and the derivative rare-element-enriched magmas. Thus, LCT pegmatites are generated in compressional tectonic settings (orogenic suites) and NYF from extensional tectonic settings (anorogenic suites). Mixed NYF and LCT are proposed to be the result of contamination, either at the magmatic or postmagmatic stage, in which the evolved NYF rocks get "soaked" with a fluid bringing in not only Li and B, but also Ca and Mg from the host rock, such that part of the pegmatite body may contain dravitic, elbaitic and liddicoatitic tourmaline, danburite, and other exotic species such as microlite, fersmite, londonite and pezzottatite. They propose that some of the exotic Madagascar pegmatites with a hybrid or “mixed” NYF / LCT character may be caused by remelting of just-formed-NYF pegmatites by such metasomatic fluids. They also propose that pegmatites may form by anatexis from both crustal and mantle rocks, which may have been previously metasomatically altered.

It is clear that a trend toward a petrogenetic classification is emerging. A petrogenetic classification that can relate pegmatites to tectonic regimes and the related magma generating processes, is essential in order to advance our understanding of pegmatite genesis within the larger-scale earth processes. The Martin and De Vito (2005) classification is a significant step in that direction. Perhaps now is the time to develop a committee to address the problems of pegmatite classification such as was done for the classification of igneous rocks by the IUGS.

**THE FOUR CLASSES OF GRANITIC PEGMATITE ČERNÝ, 1991**

| Class | Family | Typical Minor Elements | Metamorphic Environment | Relation to Granite | Structural Features | Examples |
|---|---|---|---|---|---|---|
| **Abyssal** | — | U, Th, Zr, Nb, Ti, Y, REE, Mo<br>poor (to moderate) mineralization | (upper amphibolite to) low- to high-P granulite facies<br>~4-9 kb<br>~700-800°C | none (segregations of anatectic leucosome) | conformable to mobilized cross-cutting veins | Rae and Hearne Provinces, Sask. (Tremblay, 1978); Aldan and Anabar Shields, Siberia (Bushev and Koplus, 1980); Eastern Baltic Shield (Kalita, 1965) |
| **Muscovite** | — | Li, Be, Y, REE, Ti,<br>U, Th, Nb > Ta<br>poor (to moderate) mineralization, micas and ceramic minerals | high-P, Barrovian amphibolite facies (kyanite-sillimanite)<br>~5-8 kb<br>~650-580°C | none (anatectic bodies) to marginal and exterior | quasi-conformable to cross-cutting | White Sea region, USSR (Gorlov, 1975); Appalachian Province (Jahns *et al.*, 1952); Rajahstan, India (Shmakin, 1976) |
| **Rare - Element** | **LCT** | Li, Rb, Cs, Be, Ga, Nb <,> Ta, Sn, Hf, B, P, F<br>poor to abundant mineralization, gemstock industrial minerals | low-P, Abukuma amphibolite to upper greeenschist facies (andalusite-sillimanite)<br>~2-4 kb<br>~650-500°C | (interior to marginal to) exterior | quasi-conformable to cross-cutting | Yellowknife field, NWT (Meintzer, 1987); Black Hills, South Dakota (Shearer *et al*, 1987); Cat Lake-Winnipeg River field, Manitoba (Černý *et al.*, 1981) |
|  | **NYF** | Y, REE, Ti, U, Th, Zr, Nb > Ta, F<br>poor to abundant mineralization, ceramic minerals | variable | interior to marginal | interior pods, conformable to cross-cutting exterior bodies | Llano Co., Texas (Landes, 1932); South Platte district, Colorado (Simmons *et al.*, 1987); Western Keivy, Kola, USSR (Beus, 1960) |
| **Miarolitic** | **NYF** | Be, Y, REE, Ti, U, Th, Zr, Nb > Ta, F<br>poor mineralization, gemstock | shallow to sub-volcanic<br>~1-2 kb | interior to marginal | interior pods and cross-cutting dikes | Pikes Peak, Colorado (Foord, 1982); Sawtooth batholith, Idaho (Boggs, 1986); Korosten pluton, Ukraine (Lazarenko *et al.*, 1973) |

**Table 1** The four classes of granitic pegmatite Černý (1991)

| CLASSIFICATION OF PEGMATITES OF THE RARE ELEMENT CLASS | | | |
|---|---|---|---|
| **Pegmatite type** | **Pegmatite subtype** | **Geochemical signature** | **Typical minerals** |
| **RARE-EARTH** | allanite-monazite | (L)REE, U, Th<br>(P, Be, Nb > Ta) | allanite<br>monazite |
| | gadolinite | Y, (H)REE, Be,<br>Nb > Ta, F (U, Th, Ti, Zr) | gadolinite, fergusonite,<br>euxenite, (beryl) (topaz) |
| **BERYL** | beryl-columbite | Be, Nb >< Ta (± Sn, B) | beryl<br>columbite-tantalite |
| | beryl-columbite-phosphate | Be, Nb >< Ta, P<br>(Li, F ± Sn, B) | Beryl, columbite-tantalite,<br>triplite, triphylite |
| **COMPLEX**<br>**(rare element)** | spodumene | Li, Rb, Cs, Be,<br>Ta >< Nb<br>(Sn, P, F ± B) | spodumene (amblygonite)<br>beryl (lepidolite)<br>tantalite (pollucite) |
| | petalite | Li, Rb, Cs, Be,<br>Ta > Nb<br>(Sn, Ga, P, F ± B) | petalite (amblygonite)<br>tantalite<br>beryl (lepidolite) |
| | lepidolite | F, Li, Rb, Cs, Be<br>Ta > Nb<br>(Sn, P ± B) | lepidolite microlite<br>beryl<br>topaz (pollucite) |
| | amblygonite | P, F, Li, Rb, Cs<br>Be, Ta > Nb<br>(Sn ± B) | amblygonite (lepidolite)<br>beryl (pollucite)<br>tantalite |
| **ALBITE-SPODUMENE** | | Li<br>(Sn, Be, Ta >< Nb ± B) | spodumene (beryl)<br>(cassiterite) (tantalite) |
| **ALBITE** | | Ta >< Nb, Be<br>(Li ± Sn, B) | tantalite (cassiterite)<br>beryl |

**Table 2.** Classification of pegmatites of the Rare-Element class. (Černý, 1991)

| |
|---|
| I. Abyssal Class |
| 1. potassium feldspar type |
| 2. corundum type |
| II. Rare Element Class |
| 1. beryl type (LCT) |
| 1a. beryl-columbite subtype |
| 1b. beryl-columbite-uranium subtype |
| 1c. beryl-columbite-phosphate subtype |
| 1d. chrysoberyl subtype (miarolitic or massive) |
| 1e. emerald subtype |
| 2 rare earth type (NYF) |

| |
|---|
| 2a. allanite-monazite subtype |
| 2b. monazite-thortveitite subtype |
| 2c. bastnäsite subtype |
| 3 complex type (LCT) |
| 3a. lepidolite subtype (miarolitic or massive) |
| 3b. amblygonite subtype |
| 3c. elbaite subtype (miarolitic or massive) |
| 3d. danburite subtype (miarolitic or massive) |
| III. NYF Miarolitic Class |

**Table 3.** Pegmatite classification scheme of Pezzotta (2001)

| CLASSIFICATION OF NYF-TYPE PEGMATITES MIKE WISE (1999) | | | | |
|---|---|---|---|---|
| **PEGMATITE TYPE** | **PEGMATITE SUBTYPE** | **ASSOCIATED ACCESSORY MINERALS** | **GEO-CHEMICAL SIGNATURE** | **EXAMPLES** |
| **PERALKALINE GROUP** | | | | |
| **Fayalite** | | magnetite, (hematite, ilmenite, epidote, titanite, allanite) | Fe (Ti, Ca) | Velence Mtns., Hungary; Sawtooth batholith, Idaho; Rockport, Massachusetts; Strzegom-Sobotka, Poland; Mt. Perdosu, Sardinia |
| **Amphibole** | Aegirine-Arfvedsonite | fluorite, allanite, zircon (columbite fergusonite, monazite, pyrochlore) | Na, Fe, Zr, F (± Ti, REE, Nb) | Zomba, Malawi ; Strange Lake Complex, Quebec ; Stettin Complex, Wisconsin |
| | Riebeckite | zircon, fluorite, (magnetite, rutile, ilmenite, monazite, columbite, pyrochlore) | | Mt. Rosa (St Peter's Dome), Colorado; Quincy, Massachussetts; Hurricane Mtn., New Hampshire; Granite Peak, Franklin Mtns., Texas |
| | Allanite | zircon, (beryl, apatite) | | Pacoima Canyon, California |
| **METALUMINOUS GROUP** | | | | |
| **Allanite** | Allanite | (fluorite, magnetite, monazite, zircon, ilmenite, rutile) | LREE (± Ti, Zr, F) | South Platte (south), Colorado Red Rock, Nevada; Gold Butte, Clark Co., Nevada; Amherst Co., Virginia |
| | Euxenite (Polycrase) | monazite, zircon, xenotime, ilmenite, (fergusonite, aeschynite, rutile, tourmaline) | LREE→HREE Nb > Ta, Ti, Zr, Y, P | Trout Creek, Colorado; Gloserheia, Norway; West Portland, Quebec; Evans-Lou, Quebec |
| | Gadolinite | fergusonite, xenotime, samarskite, zircon, (euxenite, ilmenite, rutile, magnetite, fluorite) | Y+HREE, Nb > Ta, Be, Ti, Zr, P, (F) | South Platte (north), Colorado Pyörönmaa, Finland Ytterby Sweden; Barringer Hill, Texas; Clear Creek, Texas |
| **PERALUMINOUS GROUP** | | | | |
| **Beryl** | Beryl | zinnwaldite, spessartine, fluorite, hematite, muscovite | Be (Li, F) | Mt. Antero, Colorado Sawtooth batholith, Idaho |
| | Tourmaline | topaz, lepidolite, fluorite. danburite, hambergite | Be, B, Li, F | Leduc, Quebec, Rangkul, Pamirs, Tadjikistan, Russia; Borshchovochny, Transbaikalia, Russia |
| | Topaz | muscovite, monazite, euxenite, fluorite, columbite, | Be, F (± B, Li) | Luumäki, Finland; Klein Spitzkoppe, Namibia; Tordal, Norway; Volhynia, Ukraine; |

| | | | | |
|---|---|---|---|---|
| | | zinnwaldite (phenakite, lepidolite, schorl, zircon, cassiterite) | | Morefield-Rutherford-Herbb #2, Virginia |
| Phenakite | | muscovite, fluorite, (topaz, beryl, bertrandite, ilmenite, zircon) | Be, F | Mt. Antero, Colorado; Pikes Peak, Colorado; South Baldface Mtn., New Hampshire; Nine Mile Pluton, Wisconsin |
| Topaz | | zinnwaldite, muscovite, fluorite, hematite, spessartine, cassiterite | F, (Be, Li, Sn) | Mt. Antero, Colorado; Sawtooth batholith, Idaho |
| Fluorite | | calcite, hematite | F | Khantau massif, Kazakhstan |

**Table 4.** Classification of NYF pegmatites, (modified from Wise, 1999).

## Systematics of Granitic Pegmatites

I. Low-Pressure Pegmatites
1. Crystal-bearing Formation
   a. Fluorite-rock crystal-bearing Subformation
   b. Subrare-metal (with precious stones) Subformation
      Miarolitic Facies Evolution Sequences: Topaz-Beryl and Tourmaline
2. Rare-metal – Rare-earth Formation
   Evolutionary Sequences: Nb-Y, F-Ta-Y and Be-REE
   Miarolitic Facies Evolution Sequences: Amazonite

II. Moderate-Pressure Pegmatites
1. Rare-metal Formation
   a. Petalite Subformation
      Evolutionary Sequences: Be, Li, P-Ta-Li, F-Ta-Li and Cs-Ta-Li
   b. Spodumene Subformation
      Evolutionary Sequences: Ta-Be, Li, Ta-Sn-Li, P-Ta-Li and Cs-Ta-Li
      Miarolitic Facies Evolutionary Sequences for the Formation as a whole: Beryl (morganite)-Tourmaline, Tourmaline-Kunzite, and Phosphate-Tourmaline

III. High-Pressure Pegmatites
1. Mica-bearing Formation
   a. Rare-metal – Muscovite Subformation
      Evolutionary Sequences: Columbite-Muscovite and Beryl-Muscovite
      Miarolitic Facies Evolutionary Sequence: Beryl-Tourmaline
   b. Muscovite Subformation
      Evolutionary Sequences: Quartz-Muscovite and A-shape Muscovite

2. Feldspar Formation

Evolutionary Sequences: U-REE and Non-specialized

**Table 5.** Systematics of Granitic Pegmatites Zagorsky, Makagon & Shmakin (1999)

**Classification of granitic pegmatites of the NYF family Ercit 2004**

| Class | Affiliation | Type | Typical Minor Elements | Metamorphic Environment (Peak Conditions) | Examples |
|---|---|---|---|---|---|
| Abyssal | None to NYF | Rare Earth | U, Th, Zr Nb, Ti, Y, REE, Mo | high P,T (6-10 kb, 700-800 °C) upper amphibolite to granulite facies | Rae & Hearne provinces, SK, Canada, Grenville province, ON-QC, Canada; Aldan and Anabar Shields, Russia |
| Muscovite | Generally none |  | (none, but giant muscovite) | high P, moderate T (5-8 kbar 580-650 °C): amphibolite facies | Mama-Vitima region, Siberia; most of the Appalachian mica belt; USA |
| Muscovite-rare-element | NYF | Muscovite--REE | Y, REE, Ta, Nb, Ti, U, Th, Be | mod-high P, moderate T (3-7 kb, 540-650 °C: amphibolite facies | Spruce Pine, NC, USA; parts of Chupa-Yena district, NW Russia |
|  | LCT | (unnamed) | Li, Be, Nb (no, Y, REE) | (as prev.) | Bihar belt, India; much of Shelby-Hickory, NC, USA |
| Rare-Element | NYF | Rare-Earth-Fluorine | REE, U, Th, Be, Nb>Ta, F | moderate-low P, moderate T (2 -4kb, 500-650 °C): upper green- schist to amphibolite fades | Barringer Hill, TX, South Platte, CO, USA; Ytterby, Sweden, Evje-Iveland, Norway, Kitsamby, Madagascar |
|  | LCT | Beryl | Be, Nb | (as prev.) | Greer Lake, MB, Canada; Hagendorf-Süd, Germany, Murzinka, Ural Mts., Russia; Donkethoek, Namibia |
|  | LCT | Complex | Li, Rb, Cs, Ta, Be | (as prev.) | Tanco, MB, Canada; Harding, NM, USA; Bikita, Zimbabwe; Greenbushes, Australia |
|  | LCT | Albite-Spodumene | Li, Sn, (Be, Ta) | (as prev.) | Preissac-Lacore, QC and Little Nahanni, NWF, Canada; Kings Mt., NC; Volta Grande, Brazil |
|  | LCT | Albite | Ta, (Sn) | (as prev.) | Hengshan, China; Tin Dike, MB, Canada |
| Miarolitic | NYF | (unnamed) | Y, REE, Ti, U, Th, Zr, Nb, F | very low P (1-1.5 kbar) | Pikes Peak, CO and Sawtooth, batholith, ID, USA; Korosten Pluton, Volyn region, Ukraine |
|  | LCT | (unnamed) | Li, Be, B, F | low P (1.5-3 kbar) | San Diego Co., CA, USA; Safira dist., |

Brazil; Sahatany Valley, Madagascar,
Hindu Kush, Afghanistan

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## Table 6. Classification of granitic pegmatites of the NYF family Ercit 2004

## Examples of granitic pegmatites of the NYF family Ercit 2004

| Class | Type | Subtype | Examples | References |
|---|---|---|---|---|
| Abyssal | Rare Earth | Allanite-monazite-uraninit | Wolverine field, Mt Bisson, BC | Halleran and Russell (1993) |
| | | | Five Mile mine, Madawaska, ON | Storcy & Vos (1981) |
| | | | Mt. Launer, QC & Sharbot Lake, ON | Henderson (1982), Ford (1982) |
| | | | St-Pierre-dc-Wakefield quarry, Gatineau, QC | Rose (1960) |
| | | | Rae & Heame provinces, SK | Tremblay (1978) |
| | | | part of Chupa-Yena dist., Karelia, Russia | Leonova & Polezhaeva (1975) |
| | | | | |
| | | Y-Nb-oxide | Party Sound, Hybla and Madawaska dists., ON | Hewitt (1955, 1967), Goad (1990) |
| | | | Evans-Lou, and Lapointe quarries, Gatineau, QC | Hogarth (1972) Spence (1932) |
| | | | Gloserheia, Norway | Bugge (1943), Amli (1975, 1977) |
| | | | Aldan, Anabar shields, Siberia, Russia | Bushev and Koplus (1980) |
| | | | Kitsamby-Antsirabé, Madagascar | Joo’ (1970), Bourret (1988) |
| | | | | |
| Muscovite-Rare-Elemen | Muscovite-REE | | Mattawa, ON | Ercit (1992) |
| | | | Spruce Pine clist, NC | Olson (1944), Lesure (1968) |
| | | | most of Chupa-Yena dist, Karelia, Russia | Leonova and Polezhaeva (1975) |
| | | | some migmatite terranes of the Ural Mts., Russia | Ayzderdzis (1976) |
| | | | | |
| Rare-Element | Rare - Earth Fluorite | Allanite monazite | Pacoima pegmatite, Los Angeles Co., CA | Moller (1995) |
| | | | southern group, South Platte dist, CO | Simmons et al. (1987) |
| | | | Helle, Kokjen and Sônnevig, Hitterö, Norway | Adamson (1942) |
| | | | most of the Oku-Tango belt, Japan | Tatekawa (1955) |
| | | Euxenite | Georgeville, NS | MurphyctaL (199 |
| | | | Trout Creek pass, CO | Hanson et 31. (199 |
| | | | Topsham, ME | Hanson et al. (1998) |
| | | | most of the southern Iveland dist., Norway | Bjorlykke (1935) |
| | | | Alto Mólocué, Mozambique | Cilek (1989) |
| | | | Otozan and Morigami pegs., Ryoke belt, Japan | Minakawa et al. (1978) |
| | | | most of the Mukinbuin field, WA, Australia | M. Jacobson (pers. comm.) |
| | | | | |
| | | Gadolinite | Shatford Lake group, MB | Cerny et al. (1981) |
| | | | White Cloud mine, South Platte dist, CO | Simmons et at (1987) |
| | | | Central Mineral dist., TX | Ehlmann et at (1964) |
| | | | most of the northern Iveland dist., Norway | Bjorlykke (1935) |
| | | | Ytterby, Osterby and Falun, Sweden | Smeds (1990) |
| | | | West Keivy, Kola Peninsula, Russia | Lunts (1972) |
| | | | Mategawa and Hama, Ryoke belt, Japan | Minakawa et at (1978) |
| | | | Cooglegong, WA, Australia | Simpson (1951) |

| | | | | |
|---|---|---|---|---|
| Miarolitic | | | Mt Antero, CO | Switzer (1939) |
| | | | Pikes Peak, CO | Foord (1982) |
| | | | Sawtooth batholith, ID | Menzies and Boggs (1993) |
| | | | Baveno, Italy | Pezzotta et at (1999) |
| | | | Luumäki, Finland | Lahti and Kinnunen (1993) |
| | | | Korosten pluton, Volyn region, Ukraine | Lazarenko et at (1973) |
| | | | Amazonitic pegmatite, Rangkul' field, Tajikistan | Skrigitil' (1996) |

**Table 7** Examples of granitic pegmatites of the NYF family Ercit 2004

**THE CLASS SYSTEM OF GEOLOGICAL, PARAGENETIC AND GEOCHEMICAL CLASSIFICATION OF GRANITIC PEGMATITES Černý & Ercit 2005**

| Class | Subclass | Type | Subtype |
|---|---|---|---|
| **Abyssal** | AB-LREE | | |
| (AB) | AB-HREE | | |
| **Muscovite** (MS) | | | |
| **Muscovite - Rare-element** | MREL-REE<br>MREL-Li | | |
| (MSREL) | | | |
| **Rare-element** | REL-REE | allanite-monazite | |
| (REL) | | euxenite | |
| | | gadolinite | |
| | REL-Li | beryl | beryl-columbite |
| | | | beryl-columbite-phosphate |
| | | complex | spodumene |
| | | | petalite |
| | | | lepidolite |
| | | | elbaite |
| | | | amblygonite |
| | | albite-spodumene | |
| | | albite | |
| **Miarolitic** | MI-REE | topaz-beryl | |
| (MI) | | gadolinite-fergusonite | |
| | MI-Li | beryl-topaz | |
| | | MI-spodumene | |
| | | MI-petalite | |
| | | MI-lepidolite | |

**Table 8**. The Class System of Geologic, Paragenetic and Geochemical Classification of Granitic Pegmatites

Černý & Ercit 2005

PRINCIPAL SUBDIVISION AND CHARACTERISTICS OF THE **FIVE** CLASSES OF GRANITIC PEGMATITES modified from Černý & Ercit 2005

| **Class**<br>***Subclass***<br>Type -Subtype | Typical minor elements | Metamorphic environment | Relation to granites |
|---|---|---|---|
| **Abyssal (AB)**<br>***AB-HREE***<br>***AB-LREE***<br>***AB-U*** | U, Th, Zr, Ti, Nb,Y, LREE; HREE poor to moderate mineralization | upper amphibolite to low- to high-P Granulite facies; ~4 to 9 kbar, ~700 to 800°C | none (segregations of anatectic leucosome) |
| **Muscovite (MS)** | Ca, Ba, Sr, Fe>Mn<br>no rare-element mineralization (micas and ceramic minerals) | high-P, Barrovian amphibolite facies (kyanite-sillimanite) *5* to 8 kbar, ~*650* to 580°C | none (anatectic bodies) to marginal and exterior |
| **Muscovite – Rare-element (MSREL)** | | | |
| ***MSREL-REE*** | Be, Y, REE,<br>Ti, U, Th, Nb-Ta: muscovite, biotite, almandine-spessartine garnet, (kyanite, sillimanite) | moderate to high P, (T) amphibolite facies; 3 to 7 kbar, ~*650* to *520°C* | interior to exterior; sometimes poorly defined |
| ***MSREL-Li*** | Li, Be, Nb<br>beryl, cassiterite, columbite, lepidolite, (spodumene) | | |
| **Rare-element (REL)** | | | |
| ***REL-REE***<br>Allanite-Monazite<br>Euxenite<br>gadolinite | Be, Y, REE, U, Th, Nb>Ta, F | variable, largely shallow and postdating regional events affecting host rocks | interior to marginal (rarely exterior) |

| | | | |
|---|---|---|---|
| ***REL-Li***<br>Beryl -B*eryl-columbite*<br>-*Beryl-columbite-phosphate*<br>Complex -*Spodumene*<br>-*Petalite*<br>-*Lepido*lite<br>-*Elbaite*<br>-A*mblygonite*<br>Albite-Spodumene<br>Albite | Li, Rb, Cs, Be, Ga, Sn, Hf, Nb-Ta, B, P, F | low-P, Abukuma amphibolite (andalusite-sillimanite) to upper greenschist facies; ~2 to 4 kbar, ~*650* to 450°C | (interior to marginal to) exterior |
| **Miarolitic (MI)** | | | |
| ***MI-REE*** | Be, Y, Nb, REE, F, Ti, U, Th,, Zr, | very low P, postdating regional events that affect host rocks | interior to marginal |
| ***MI-Li*** | Li, Be, B, F, Ta>Nb | low-P amphibolite to greenschist, 3 to 1.5 kbar, 500 to 400°C | (interior to marginal) to exterior |

**Table 9**. Principal Subdivision and Characteristics of the Five Classes of Granitic Pegmatites Černý & Ercit 2005

THE FAMILY SYSTEM OF PETROGENETIC CLASSIFICATION OF GRANITIC PEGMATITES OF PLUTONIC DERIVATION Černý & Ercit 2005

| **Family** | **Pegmatite subclass** | **Geochemical signature** | **Pegmatite bulk composition** | **Associated granites** | **Granite bulk composition*** | **Source lithologies**** |
|---|---|---|---|---|---|---|
| | | | | | | |
| LCT | REL-Li<br>MI-Li | Li, Rb, Cs, Be, Sn, Ga, Ta>Nb, (B, P, F) | peraluminous to subaluminous | **synorogenic to late-orogenic (to anorogenic)**; largely heterogeneous | peraluminous, S, I or mixed S+I types | Undepleted upper- to middle-crust supracrustals and basement gneisses |
| | | | | | | |
| NYF | REL -REE<br>MI-REE | Nb>Ta, Ti Y, Sc, REE, Zr, U, Th, F | subaluminous to metaluminous (to subalkaline) | **syn-, late, post-** to **mainly anorogenic**; quasi-homogeneous | pera!uminous to subaluminous and metaluminous; A and I types | depleted middle to lower crustal granulites, or juvenile granitoids |
| | | | | | | |
| Mixed | Cross-bred: LCT & NYF | mixed | metaluminous to moderately peraluminous | **postorogenic to anorogenic;** heterogeneous | subaluminous to slightly peraluminous | mixed protoliths or assimilation of supracrustals by NYF granites |

Table 10 The Family System of Petrologic Classification of Granitic Pegmatites of Plutonic Derivation Černý & Ercit 2005

Potential subdivisions in the LCT family:

| | |
|---|---|
| LCT-I | fertile granites generated by low-percentage anatexis of igneous protoliths and subsequent extensive differentiation; subaluminous fertile granites and derived pegmatites poor in B, P, S, with relatively low $\delta^{18}O$ ; *e.g.*, the Greer Lake leucogranite + pegmatite suite, MB (Černý *el al*. 2004a); part of the Yellowknife field – Meintzcr |

| | |
|---|---|
| | (1987) |
| LCT-S | fertile granites generated by anatexis of metasedimentary protoliths and subsequent differentiation; peraluminous fertile granites and derived pegmatites enriched in B, P, S, with high $\delta^{18}O$; *e.g.* the Osis Lake leucogranite + pegmatite suite, MB (Černý & Brisbin 1982), and the Preissac-Lacorne suite, QC (Mulja *et al.1995,* Ducharme *et al.* 1997) |

Potential subdivisions in the NYF family:

| | |
|---|---|
| NYF-A | anorogenic granites, as members of bimodal gabbro-granite suites, generated by partial melting of depleted lower crust; fluorite-bearing largely metaluminous (to subalkaline) pegmatites with the prototype” NYF signature; *e.g.,* the South Platte granite + pegmatite system, CO (Simmons *et al.* 1987), and the Grotingen granite + Abborselet and other associated pegmatites, Sweden (Kjellman *et al.* 1999) |
| NYF-I | syn- to late-orogenic granites generated by high-percentage anatexis of igneous protoliths and subsequent moderate differentiation; topaz-bearing pegmatites; *e.g.,* the Lac du Bonnet biotite granite + Shatford Lake pegmatite group, MB (Buck *et al.* 1999), and the Stockholm granite + the Ytterby pegmatite group, Sweden (Kjellman *et al.* 1999) |

*peraluminous, A/CNK>1; subaluminous, A/CNK~1; metaluminous, A/CNK<1 at A/NK>1; subalkaline, A/NK~1; peralkaline, A/NK<1, where $A = Al_20_3$, $CNK = CaO + Na_2O + K_2O$, and $NK = Na_2O + K_2O$ (all in molecular values; Černý 1991).