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■ 제 3 발표장

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시 간	제 목	저자 및 소속	좌 장
11:00-11:20	Mineralogical evolution of the Sokli phoscorite-carbonatite complex, Kola Peninsula, Finland	Mi Jung Lee(KORDI), Daniel Garcia, Jaques Moutte(Centre SPIN, Ecole des Mines), Jong Ik LEE, Yeodong Kim(KORDI)	김진섭 (부산대) 홍세선 (지질자원 연구원)
11:20-11:40	Petrogenesis of the ultramafic rocks from the Hongseong and Kwangcheon area, western part of Chungnam	Suckhwan Song(Joongbu Univ.), Seon Gyu Choi(Korea Univ.)	
11:40-12:00	Mineralogy and Geochemistry of Ultramafic Rocks from the Bibong and Baekdong Areas in the Western Korea: Its Genetic Implication	Ji-Eun Seo, Seon-Gyu Choi(Korea Univ.), Chang-Whan Oh, Sung-Won Kim(Chonbuk Univ.), Suck-Hwan Song(Joongbu Univ.)	
12:00-12:20	He-Ar and Nd-Sr isotopic compositions of ultramafic xenoliths and host alkali basalts from the Korean peninsula	Kim Kyu Han(Ewha Womans Univ.), Keisuke Nagao(Univ. of Tokyo), Tsuyoshi Tanaka(Nagoya Univ.), Hiroshica Sumino(Univ. of Tokyo), Toshio Nakamura (Nagoya Univ.), Mitsuru Okuno(Fukuoka Univ.), Y. Ishitsuka(Nagoya Univ.), Jin Baeg Lock(Qiaonguang Sci. Tech. Res. Inst.), Song Jeehye(Ewha Womans Univ.)	
12:20-12:40	하와이 섬의 화산형태와 최근 분출	황상구(안동대), 이문원, 원종관 (강원대)	
12:40-15:30	중식, 정기총회, 김옥준상 시상식, 강연회		
15:30-15:50	Synthesis Research on Targets in Ore-forming Zone of Yulong, Xizang (Tibet), China	Chen Jianping(China University of Geosciences, Beijing), Tang Juxing, Li Zhijun(Chengdu Univ. of Tech.)	유인창 (경북대) 이찬희 (공주대)
15:50-16:10	Genetic Environments of the Eunsan and Moisan Epithermal Gold-silver Deposits in the Haenam Basin	Chang Seong Kim, Seon-Gyu Choi(Korea Univ.), Bong Chul Yoo, Hyun Koo Lee(Chungnam Univ.), Sahng-Yup Kim(Sun Shin Gold Mines)	
16:10-16:30	경상분지 백악기 금속광화작용: 지구동력학적 관점에서 재조명	최선규, 소칠섭, 이상열(고려대), 유인창(경북대), 위수민(교원대), 김창성(고려대), 박맹언(부경대)	
16:30-16:50	Geodynamic Setting of Mesozoic Precious-metal Deposits in Korea	Choi Seon-Gyu, So Chil-Sup, Sang Joon Pak(Korea Univ.), Ryu In-Chang(Kyungbuk Univ.), Oh Chang-Whan(Chonbuk Univ.)	
16:50-17:10	국내 금속 광상의 성인유형별 지질-환경 특성	최선규, 박상준(고려대), 이평구(지질자원연), 김창성(고려대)	
17:10-17:30	삼보 금 광상의 광물 및 지화학적 연구	박상준, 최선규(고려대), 유봉철(충남대), 강홍석, 최동호 (광진공)	

513

Mineralogical evolution of the Sokli phoscorite-carbonatite complex, Kola Peninsula, Finland.

Mi Jung Lee^{1)*}, Daniel Garcia²⁾, Jaques Moutte²⁾, Jong Ik LEE¹⁾, Yeadong Kim¹⁾

1. Introduction

The Sokli complex (NE Finland, 370 Ma) is one of the numerous carbonatite-alkalic rock complexes of the Kola Alkaline Province. The complex has a concentrically zoned structure, largely being divided into two zones, and is surrounded by fenite aureole of 1-2 km width. The outer zone mainly consists of ultramafic rocks which were largely transformed into carbonate-bearing metasomatic facies by CO₂-rich fluids derived from later carbonatite injections. The inner zone (phoscorite-carbonatite complex, PCC), called "magmatic core", is made up of multi intrusions of carbonatites and phoscorites (olivine or mica-magnetite-apatites with essential carbonate) and bears the largest Nb mineralization in Europe. In the magmatic core, five intrusive stages of phoscorites and carbonatites are distinguished based on mineral assemblage and bulk rock composition. The first three stages comprise phoscorites and calcite carbonatites referred to as P1 to P3 and C1 to C3, and they usually occur as pairs with same mineral assemblage. The last two stages comprise only dolomite carbonatites called D4 and D5. These rocks are poorly exposed at the surface, but numerous drill core samples provide fresh material for mineralogical analysis. Here, we report mineralogical data and focus on the relationships between calcite carbonatites, phoscorites and dolomite carbonatites.

2. Mineralogical evolution

Carbonatites and phoscorites display a close association, and consist of the same major and minor minerals such as olivine, phlogopite, magnetite, carbonates, apatite, pyrochlore and baddeleyite. If the carbonate minerals, which are essential phases for all carbonatites and phoscorites, are excluded, the mineral assemblages and modal proportions in each calcite carbonatite-phoscorite pair vary as follows: P1C1 rocks is composed of major olivine, magnetite, apatite and accessory baddeleyite; P2C2 pair contains major magnetite, apatite, olivine and phlogopite and accessory pyrochlore and baddeleyite; P3C3 pair dominantly consists of magnetite, phlogopite, apatite with accessory pyrochlore (Fig. 1).

KEYWORDS: phoscorite, calcite carbonatite, dolomite carbonatite, Sokli, Finland, Kola Peninsula

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Among carbonates, the dolomite proportion slightly increases from stage 1 towards stage 3. D4 dolomite carbonatite has relatively pure composition with small amounts of phlogopite, apatite, magnetite and pyrochlore. D5 is heterogeneous and characteristically contains a large number of carbonates: REE carbonates, some siderite, etc. and a high amount of sulfide minerals. In carbonatites and phoscorites of a given stage, all major minerals have broadly similar compositions and variation trends, but pyrochlore show slight differences in trends. Moreover, phlogopite and apatite in phoscorites often show complex zoning patterns and cover the large compositional ranges, whereas, the zoning patterns are much simpler and the compositional ranges much more restricted in paired carbonatites.

Magnetite

The amount of magnetite in carbonatites and phoscorites gradually increases from stage 1 towards stage 3, and its morphology changes from anhedral to euhedral. Its main compositional change from early to late generations is a decrease in Mg, Al, Mn and Ti contents, and evolution toward pure magnetite composition.

Phlogopite

The most striking evolution of phlogopite is the decrease in Al content from stage to stage, leading from a slightly eastonite-bearing phlogopite in stage 1 to pure tetraferriphlogopite from stage 3, which results mainly from Al depletion of the parental melts. Fluorine content of phlogopite shows a gradual increase, a feature observed also in the other F-bearing minerals.

Apatite

The Sokli apatite is a fluor-apatite with high F contents. F, Sr and Na increase regularly from stage 1 to stage 4, and rises more strongly between stage 4 and the latest, D5 dolomite carbonatite.

Pyrochlore

A peculiarity of Sokli is its high content of pyrochlore. It appears firstly in stage 2, increases strongly in content, locally to the percent level, in stage 3, and it continues up to the latest D5 dolomite carbonatite. Textures show that pyrochlore crystallizes relatively late, after crystallization of most other minerals, olivine, magnetite, calcite, phlogopite, and baddeleyite. The general evolution scheme is that early pyrochlore has high contents in U and Ta; these elements suddenly decrease in the intermediate stage pyrochlore, while Th and Ce increase. Late stage pyrochlores are low in Ta, U, Th and Ce, and correspondingly high in Nb. Altogether, the Nb/Ta ratios and F contents of pyrochlores increase from P2C2 to the latest D5 dolomite carbonatite. Chemical variations of Ta, Th, Ce and F in pyrochlores from phoscorites and associated carbonatites are generally unique, but the distributions of U, Ti and Zr show more complex variation: Zr are higher in calcite carbonatites, whereas Ti and U is higher in paired phoscorites.

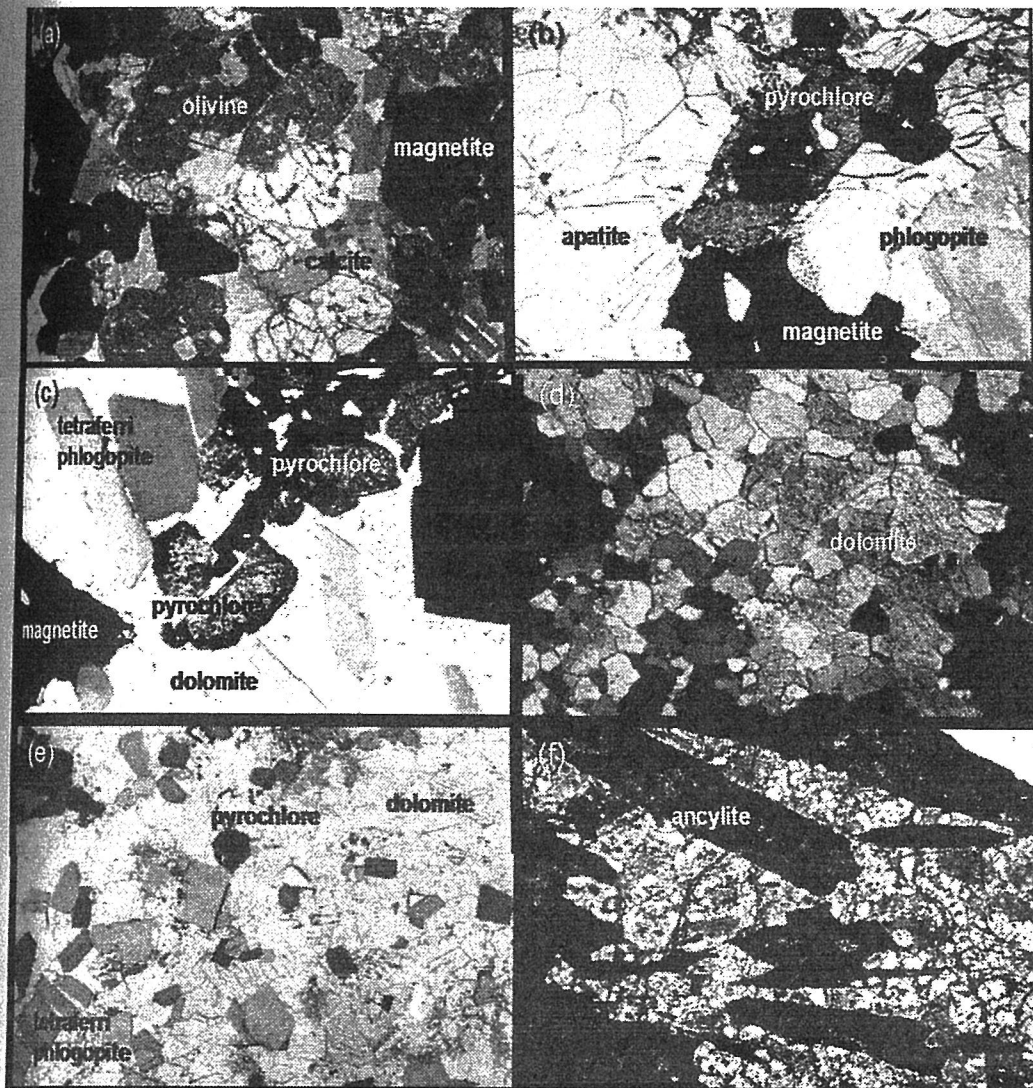


Fig. 1. Microscopic features of the Sokli phoscorites and carbonatites according to the evolutionary stages. (a) PIC1 rocks mainly consist of euhedral magnetite, olivine and calcite with subordinate apatite and phlogopite. Baddelyeite is the only Nb-Zr mineral (stage 1 phoscorite, cross, width = 1.3 mm), (b) Modal proportions of apatite and phlogopite in P2C2 rocks increase. U-Ta rich red pyrochlore begin to crystallize (stage 2 phoscorite, open, width = 2.5 mm), (c) Ce-Th rich yellow pyrochlore and euhedral tetraferriphlogopite are characteristic minerals in P3C3 rocks (stage 3 phoscorite, open, width = 2.5 mm), (d) Pure dolomitic D4 carbonatite (stage 4 dolomite carbonatite, cross, width = 1.3 mm), (e) Euhedral tetraferriphlogopite is the main silicate mineral in D5 dolomite carbonatite (stage 5 dolomite carbonatite, open, width = 6.3 mm) and (f) Ancyrite ($\text{SrCe}(\text{CO}_3)_2$) in D5 (stage 5 dolomite carbonatite, open, width = 6.3 mm).

3. Conclusions

There is a close mineralogical correspondance between phoscorites and paired calcite carbonatites, and the same evolution trend on major minerals is identified in both rock types. This trend involves a sustained increase in alkalinity and it is tentatively attributed to deep differentiation of a mixed carbonate-silicate-phosphate (Fe-rich) parental melt. However, detailed examination of minerals, especially, on late stage minerals, i.e., phlogopite and pyrochlore indicates that the chemical condition in which these minerals crystallized was clearly different in the two systems.

The two associated rocks are considered to have been derived from a common parental magma enriched in Fe, Si, P and carbonates, and their geochemical contrasts to have been produced during the separation of two rocks from the parental magma. The mineralogical records suggest that each magmatic pulse segregates at upper levels to produce a phoscorite/calcite carbonatite pair with a distinct mineralogy. The liquid immiscibility process most simply explains a large chemical gap and different mineralogical records in late stage of phoscorites and conjugated carbonatites. Therefore, liquid immiscibility is favored for explaining the chemical fractionation observed in the Sokli PCC.

Fe-Mn dolomite carbonatites, locally enriched in Sr, Ba and LREE, are the latest products from the residual (still Mg-rich) melt left after the crystallization of the Ca-carbonatites and phoscorites.