PETROLOGY AND GEOCHEMISTRY OF THE PTARMIGAN BASIN PLUTON, CHAFFEE COUNTY, COLORADO

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The Ptarmigan Basin pluton is a small Early Proterozoic granitic body located in the central Sawatch Range of Colorado. It spans an area of approximately 1.5 to 2 square miles, although its northern portion is obscured by glacial till and talus (fig. 1). The rocks of the Ptarmigan Basin pluton are light colored, fine to medium grained, and usually strongly foliated. Plagioclase, quartz, and biotite (sometimes hornblende) and minor amounts of potassic feldspar are visible in hand specimen. Contacts with the amphibolitic to pelitic wall rocks are usually concordant, and the internal foliation within the pluton is usually parallel to that in the wall rocks. Throughout the pluton, there are many tabular to irregular xenoliths of amphibolite and biotite gneiss ranging from 1 to 20 cm thick. The length of the xenoliths varies from a few centimeters (as in the case of the thin whisps) to more than two or three meters. The xenoliths are usually concordant with foliation, although they may be fractured and filled by the pluton at an angle to the foliation.

The Ptarmigan Basin pluton was mapped by Brock and Barker (1972) in the Mt. Harvard 15 -minute quadrangle as an isolated offshoot of the Kroenke Granodiorite, the southern contact of which occurs 6 miles to the north. The main Kroenke Granodiorite pluton covers an area of approximately 49 square miles and has been dated at about 1.7 billion years. Barker (1976) describes the Kroenke Granodiorite as an intrusive, discordant body with contacts between the pluton and wall rocks being brecciated in a zone 2 to 30 m thick. The pluton is described as cutting across its wall rocks in most places and locally having chilled margins. Internally, it is described as being mostly massive with few zones of foliation (Barker, 1974).

The Kroenke Granodiorite is categorized petrologically as a trondhjemite to leucoquartz diorite. In hand specimen, it is fine to medium grained and light gray to buff colored. Mineralogically, it is calcic oligoclase, quartz, potassic feldspar, and biotite and/or hornblende. The plagioclase to K-feldspar ratio is approximately 3:1. Traces of sphene, apatite, allanite, Fe-Ti oxides and calcite or siderite have been found in the Kroenke Granodiorite (Barker, 1974).

Barker (1974) states that the Kroenke Granodiorite is postkinematic and that the Ptarmigan Basin granodiorite is synkinematic. However, reconnaissance of the Kroenke Granodiorite at its type locality around Kroenke Lake indicates that it is usually well foliated and concordant with the foliation of the amphibolitic wall rocks. The Kroenke Granodiorite also contains numerous xenoliths, both whispy and intact, which are aligned parallel to foliation. Brock and Barker's map of the Mt. Harvard 15 - minute quadrangle shows the Kroenke Granodiorite with foliation symbols mapped throughout the pluton, indicating that the pluton is not wholly massive, but is instead generally well-foliated, concordant, and therefore presumably synkinematic like the Ptarmigan Basin pluton.

Petrographic studies of thin sections from the Ptarmigan Basin pluton show that all samples contain plagioclase (An_{24} to An_{32}), microcline, quartz, and varying amounts of biotite, chlorite and hornblende. Trace minerals include sphene, apatite, zircon, allanite, epidote, muscovite, and ilmenite. The alkali feldspar compositions range from nearly all microcline with minor myrmekitic plagioclase to samples entirely void of potash feldspar. However, in samples containing potassic feldspar, its growth appears to be a late event, as indicated by the "consumption" of plagioclase by microcline and by the presence of myrmekitic intergrowths in plagioclase. The name "trondjhemite" would fit only 17 % of the samples on the basis of modal analysis (estimated modes of thin sections and point-counted modes of stained slabs), the others being too high in potassic feldspar and being better termed monzogranite, granodiorite, quartz monzonite, or quartz monzodiorite. The myrmekitic textures of the Ptarmigan Basin pluton samples imply that the granodiorite was "wet" (subsolvus, S-type). However, the mineralogy of the Ptarmigan Basin pluton, high in plagioclase and containing hornblende and sphene, more closely resembles that of an I-type granite.

Major element XRF analysis of 15 samples from the Ptarmigan Basin pluton was conducted at the University of Massachussetts at Amherst using the multichannel x-ray spectrophotometer facilities supervised by Dr. J. M. Rhodes. The samples contain between 66.75 and 76.93 percent SiO_2. Alumina values range widely from 10.84 to 17.89 percent, with the average value being 14.00 percent. Most samples are peraluminous. Mean values of soda and potash oxides are 4.56 percent and 2.91 percent respectively. The average content of CaO is 1.71 percent, although it ranges from 0.68 to 3.39 percent. On an Alk-F-M diagram, samples from the pluton are distinctly within the calc-alkaline field (fig. 2). Harker-type variation diagrams for CaO, Al_2O_3, and MgO show a typical decrease with increasing SiO_2; K_2O shows an increase with increasing SiO_2, but the trends for iron and soda are anomalous.

The major element weight percentages were used to calculate CIPW normative values. On a normative Q-Ab-Or diagram, a third of the samples fall within the monzogranite field and two-thirds plot as granodiorite (fig. 3).

Five of the samples analyzed by XRF were also sent out for neutron activation analysis for the following elements: La, Ce, Sm, Eu, Tb, Yb, and also Rb, Ba, Th, Hf, Ta, Co, Sc, and Cr. Chondrite normalized rare-earth values are plotted in Figure 4, which reveals essentially two populations. Two of the samples, both monzogranites, show higher values of the HREEs than the other samples and a negative Eu anomaly. The most calcic of all the samples, a granodiorite with CaO = 3.39%, shows a slight positive Eu anomaly. The remaining two samples, also granodiorites, have a negative slope with essentially no Eu anomaly. All samples are relatively enriched in LREEs with La_N/Lu_N ranging from 7.2 to 43. The REE plots of the Ptarmigan Basin granodiorites follow a trend characteristic of continental trondhjemites as described by McBirney(1984). All of the samples are enriched in LREEs and depleted in the HREEs compared with oceanic or island arc tronhjemites, which have fairly flat REE patterns. The Eu anomalies of the monzogranites and granodiorites plot as nearly mirror images of each other along a sloping line of symmetry. This feature could be the result of the production of two phases in the evolution of the pluton, a more highly differentiated product and a cumulate.

The extent of interaction between xenoliths and pluton may have caused local variations in mineralogy and chemistry. The sample that contains the lowest percentages of SiO_2 and K_2O and the highest amounts of CaO, Na_2O and Al_2O_3 was taken from an area containing many xenoliths; the hand specimen itself contains a whispy remnant of a xenolith. However, another sample taken directly from the contact zone has an average composition for Ptarmigan Basin granodiorite. At this sample site, xenoliths were both whispy and intact, although care was taken to avoid incorporating xenolith material while sampling.

Trace-element data are still incomplete for the Ptarmigan Basin pluton, so an assessment of the mode of origin of its magma may be premature. Several models have already been proposed for the generation of trondhjemitic liquids, however. Barker (1976) describes the trondhjemitic Kroenke Granodiorite as being derived from the wet, partial melting of metabasalt. The wall rocks which surround the Ptarmigan Basin pluton contain abundant amphibolite which is likely metamorphosed basalt or sediment derived from basalt. Pillow structures were observed in similar amphibolites near Mirror Lake, about 7 km to the southwest.

Another model was proposed by Taylor and McLennan (1985) for the generation of Archean bimodal basic-felsic igneous rocks, where trondhjemites are the common felsic component. Parital melting in the upper mantle produces vast amounts of basalt, some of which then sinks and later is converted to garnetiferous granulite or eclogite. These rocks are then remelted in the mantle to generate the felsic rocks. The resultant REE pattern for the Archean felsic suite is comparable to the REE plots for the granodioritic members of the Ptarmigan Bake pluton; the steep patterns with relative depletion of HREEs being due to the presence of garnet as a residual phase.

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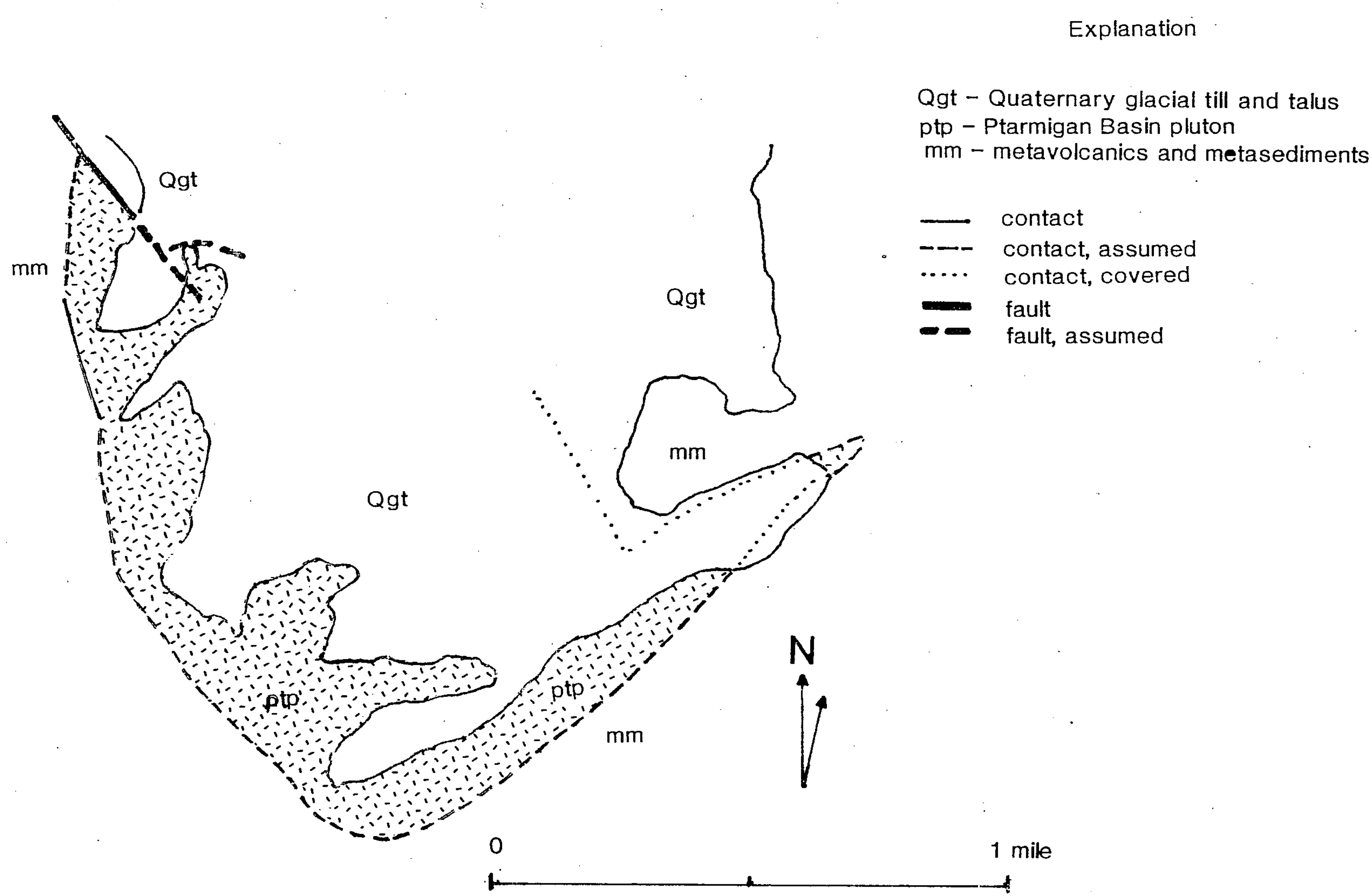

Figure 1. Geologic map of Ptarmigan Basin pluton.

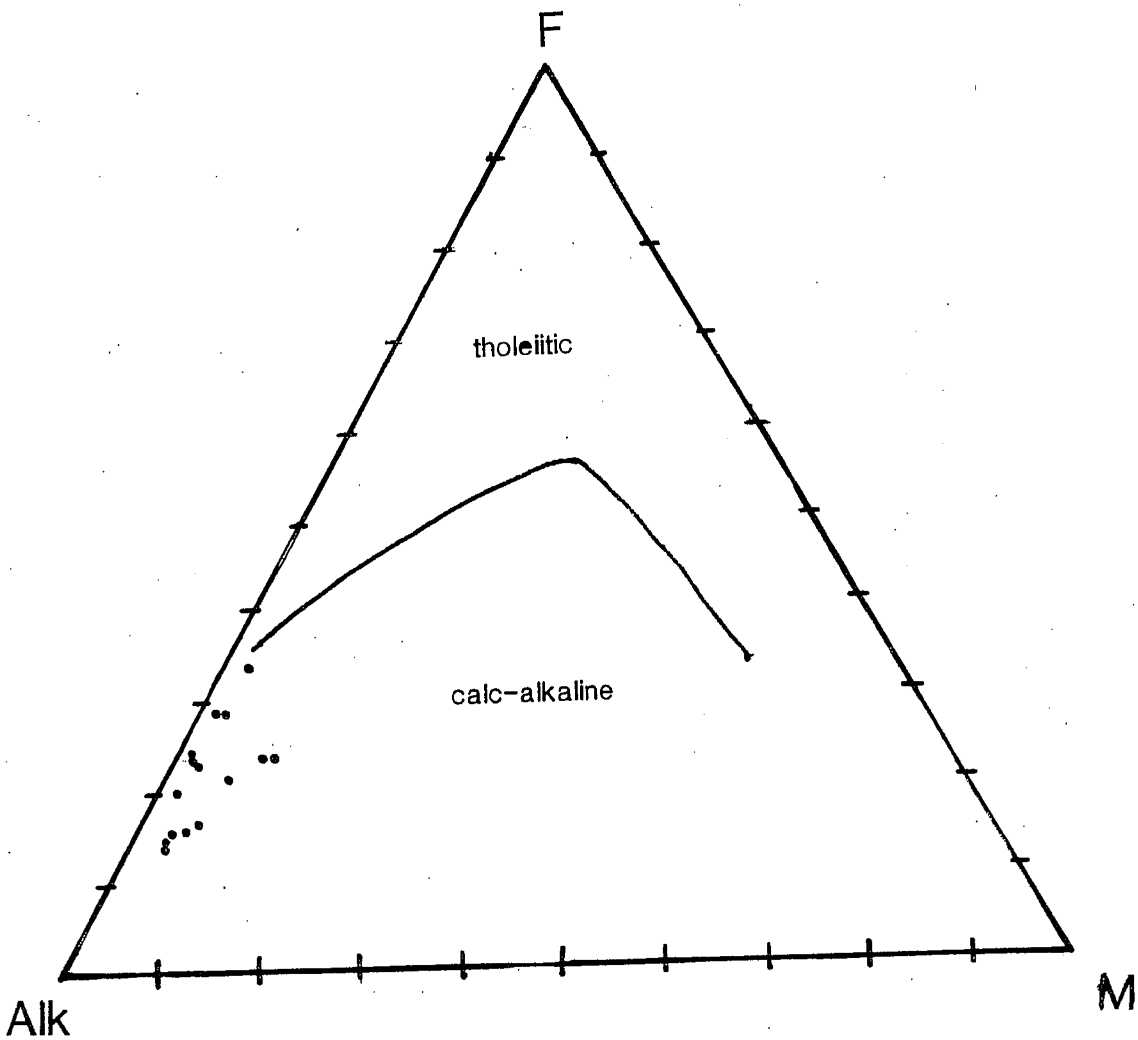

Figure 2. Alk–F–M diagram for Ptarmigan Basin pluton.

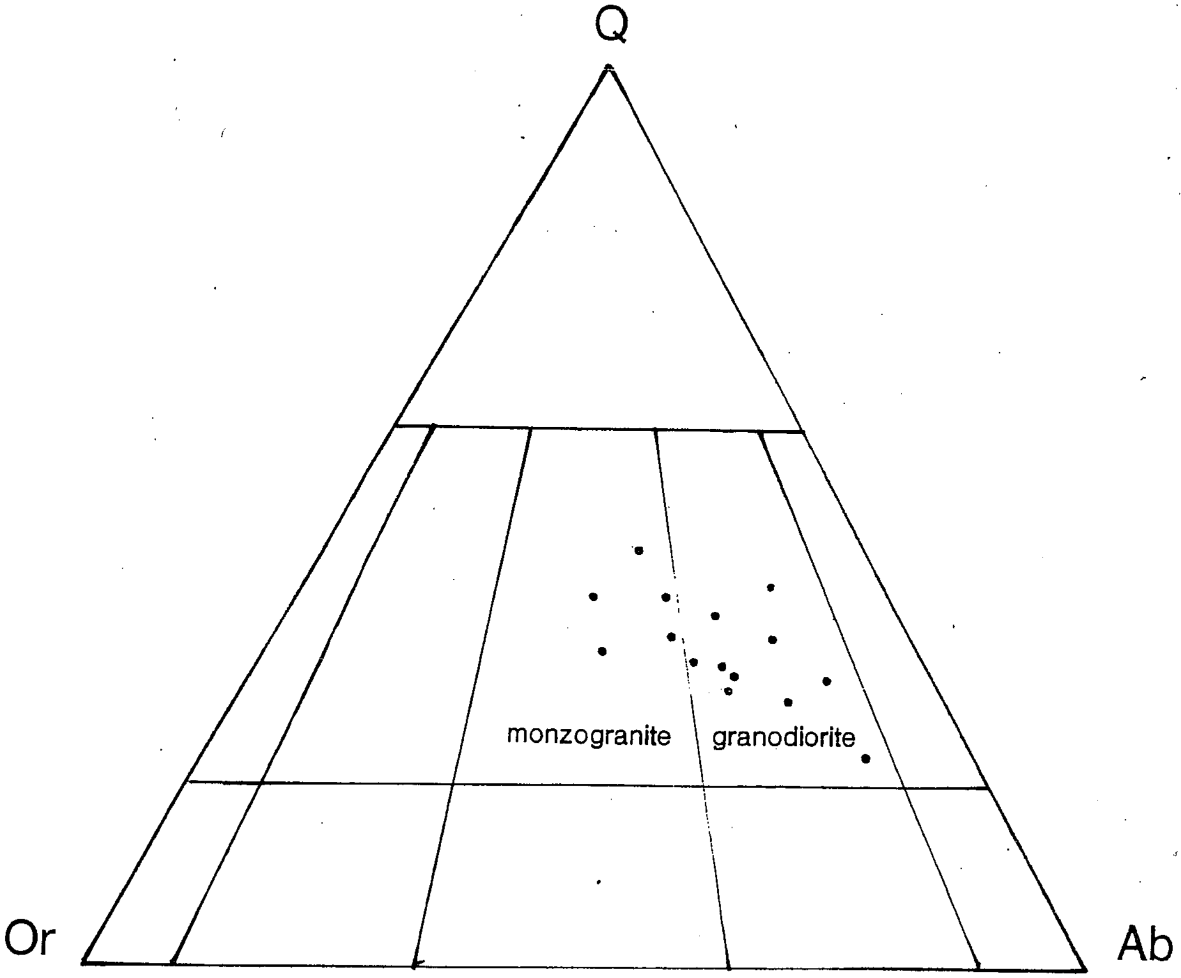

Figure 3. Normative quartz – albite – orthoclase diagram for Ptarmigan Basin samples.

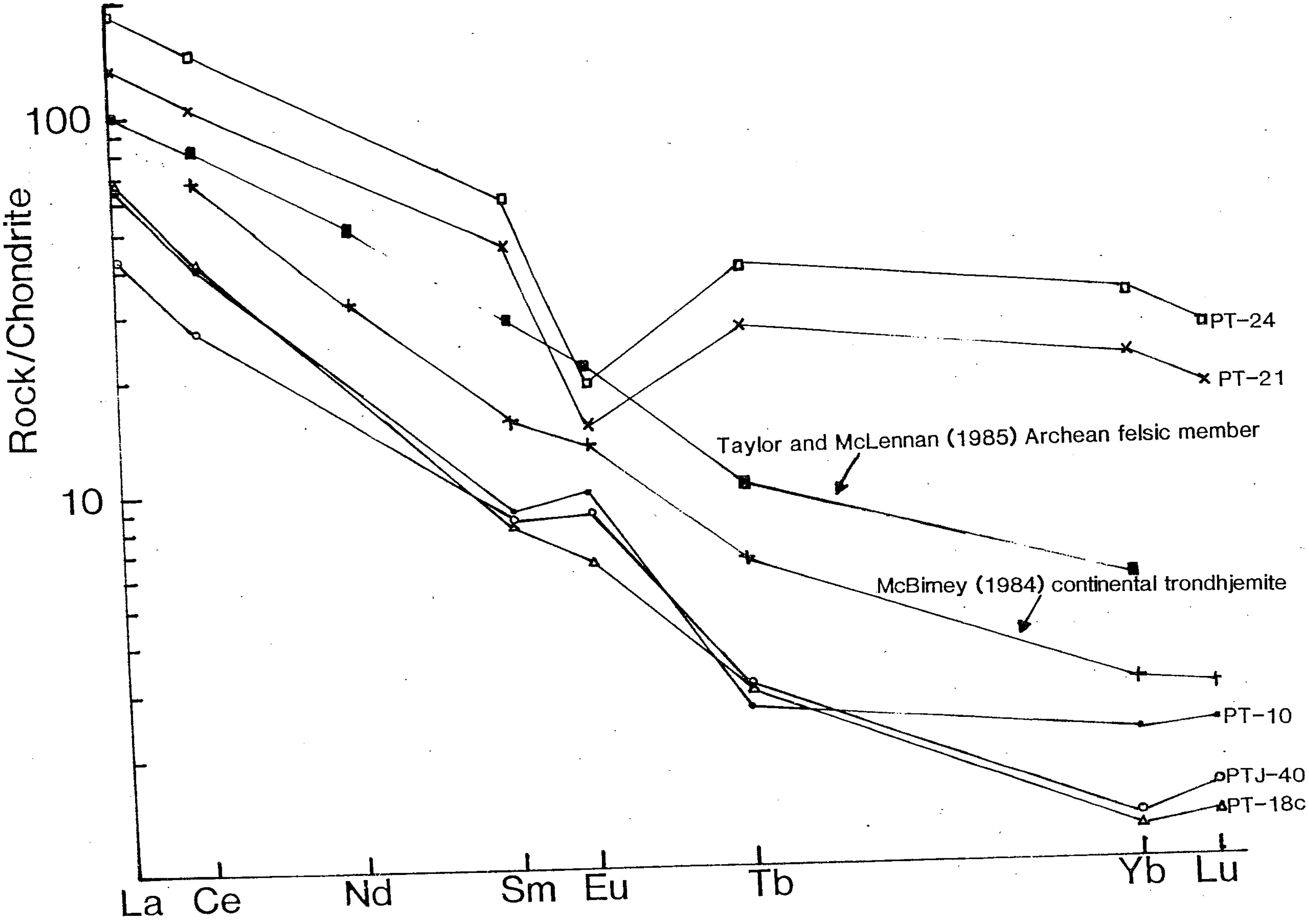

Figure 4. Chondrite – normalized REE compositions of rocks from Ptarmigan Basin pluton.