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14 Field Studies of Plutons

14-1. Rock Units, Ages, and Depth Relations

The term *pluton* is used here in a general sense, implying only a subjacent body large enough to map to scale, typically intrusive but not necessarily so. Plutons may occur singly but typically are in groups, commonly forming linear chains of separate plutons or belts of overlapping plutons. The great batholiths that evidently formed beneath volcanic arcs, such as the Coastal Batholith of the Peruvian Andes, are composed of hundreds of plutons (Pitcher, 1978).

A pluton may consist of one rock unit or more than one, and nearby plutons may consist of the same unit(s) or of different ones. The most crucial step in mapping plutons is coming to know these rock units as exactly as possible. Ideally, one should be able to recognize a specific unit whether it recurs in another pluton tens of kilometers away or as a few inclusions in a dike nearby. Rock units must therefore be based on all primary features possible: (1) proportions among specific varieties of minerals; (2) all aspects of texture (Sections 4-4 and 14-2); and (3) kinds, shapes, and sizes of inclusions, layers, and schlieren (Sections 14-3, 14-4, and 14-5). Associated dikes, pipes, veins, and alterations may be helpful if they reflect the unit's original magmatic constitution; for example, its content of volatile substances or its tendency to segregate late-stage melts (Sections 14-6 and 14-7).

These fundamental mapping units have commonly been called *plutonic units* and are equivalent to formations in sedimentary rocks or to the lithodemes of the stratigraphic code (Section 5-3). Lesser units might be local textural or altered variants that are modifications of a given plutonic unit. A plutonic unit might thus have a *foliated facies* near certain contacts or a local *sericitic zone* due to superimposed alteration.

Plutonic units may be assembled into *plutonic suites* on the basis of features or relations indicating a close genetic relation. Chief among these indicators are geographic association, similar age, and minerals and mineral reactions indicating chemical affinity. A close genetic relation can be checked in the laboratory by determinations of numerical ages, chemical compositions, and isotopic compositions.

Plutonic suites are important because they give a basis for judging the source and history of magmatic sequences. For example, Shaw and Flood (1981) were able to classify a series of plutonic suites into *S-type suites* (thought to be derived mainly by melting of metasedimentary rocks) and *I-type suites* (derived from igneous or metaigneous rocks). This particular

distinction was based largely on isotopic compositions of Sr, O, and S, but S-type suites were also indicated by minerals reflecting a high Al content (presence of cordierite, Al-rich garnet, or an Al_2SiO_5 polymorph), and I-type suites by minerals indicating relatively low Al content (hornblende with or without augite). Pitcher (1984) has summarized the characteristics and geologic environments of these two suites and two others, and has discussed pertinent literature.

Contacts between plutons and country rocks are usually distinct and readily mapped. Sharp contacts may be irregular due to blocky reentrants, cuspate forms, or folds, and these features should be mapped to scale, if possible, or recorded by suitable notes or by some design on the map. Where the contact is a broad gradation, the line is generally placed at the center of the gradation or where the plutonic rock forms a more or less continuous matrix around inclusions of country rock. In some cases two adjoining zones of mixed rocks can be mapped (Fig. 14-1). Pluton margins are likely to be broadly schistose or mylonitic in plutons emplaced diapirically when the body was more than 70% crystallized, and the contact may lie within this broad zone of ductile shear (Soula, 1982).

Dikes near the contact generally are of great value in interpreting a pluton's evolution. They may belong to one of these age groups: (1) dikes associated with the pluton but cut by it (Fig. 14-2*A*); these dikes may record the composition of the first magma emplaced at the observed level; (2) apophyses connected to the pluton, which, if porphyroaphanitic, will indicate the proportion of crystals to melt at this margin; (3) dikes emplaced when the pluton was still mobile and probably contained some melt (Fig. 14-2*B*); (4) dikes without chilled margins, emplaced in the pluton when it was still hot; and (5) dikes with chilled margins, emplaced in the pluton after it had cooled.

Contacts between rock units within plutons may be obscure where two rocks are almost identical or where they grade to one another. Such contacts may be marked by: (1) small differences in color and texture; (2) inclusions, schlieren, or layers in the younger rock, commonly forming a zone parallel

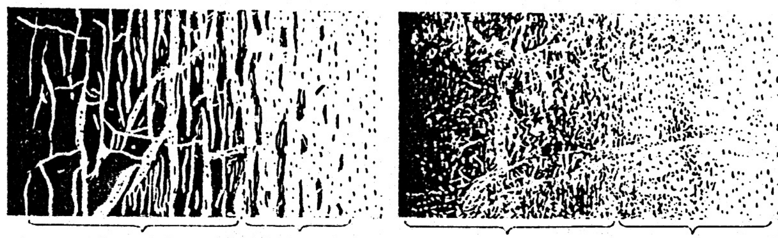

Fig. 14-1. Diked (*left*) and migmatitic gradational margins of plutons.