Mineralogical Magazine, December 2002, Vol. 66(6), pp. 1003–1019

Origin of reverse zoning in branching orthopyroxene and acicular plagioclase in orbicular diorite, Fisher Lake, California

D. G. DURANT* AND A. D. FOWLER

University of Ottawa, Department of Earth Sciences, 140 Louis Pasteur, Ottawa, Ontario K1N 6N5, Canada

ABSTRACT

An orbicular diorite from Fisher Lake, California, USA, contains multi-shelled, magmatic orbicules with branching and budding orthopyroxene crystals as well as feather and acicular plagioclase crystals that are oriented perpendicular to the growth horizon. Plagioclase and orthopyroxene show gradual, reverse compositional zoning along the long axes and normal zoning along the short axes. The reverse zoning varies from An_{87} to An_{93} and Mg_{68} to Mg_{74} over distances of 4 mm and 8 mm respectively. The close proximity of these two minerals makes it likely that only one mechanism is responsible for the reverse zoning. This zoning can be explained by using relevant temperature-composition diagrams and Gibbs free energy-composition plots. Under sudden and moderate undercoolings, which produce high growth but low nucleation rates, the difference in Gibbs free energy (ΔG) between the crystals and liquid is not initially maximized, i.e. initial compositions are not near-to-equilibrium. This results in crystal compositions that are closer to that of the bulk liquid than expected for crystallization under near-to-equilibrium conditions (i.e. very small ΔT). Over time, and under isothermal crystallization conditions, ΔG gradually increases to a maximum producing crystal compositions that also gradually attain near-to-equilibrium compositions. Subsequent to attaining these conditions, normal zoning occurs perpendicular to the crystal growth axes.

KEYWORDS: reverse zoning, orthopyroxene, plagioclase, orbicular diorite, comb texture, unidirectional growth, orbicules, branching, feather, Fisher Lake, California.

Introduction

THE Fisher Lake orbicular diorite is part of the Sierra Nevada batholith located in the eastern foothills not far from Reno, Nevada, USA (Fig. 1). This area consists of numerous, small, Jurassic, composite plutons. The Fisher Lake orbicules and associated comb layering occur within gabbro and diorite in two small areas, <0.5 km^2, located close to the granodiorite contact in a multi-phase, composite, diorite pluton (McKinney, 1985; Moore and Lockwood, 1973).

The magmatic orbicules range in size from a few cm to several dm and average ~20 cm in diameter. They contain a central core composed of subhedral crystals of plagioclase, amphibole and orthopyroxene surrounded by concentric shells that alternate in composition from predominantly felsic to predominantly mafic (Fig. 2). The felsic shells contain crystals of gradually, reverse-zoned, branching or budding, orthopyroxene (Fig. 3) and feather plagioclase (Fig. 4) that grew perpendicular to the core along with minor amounts of anhedral amphibole, magnetite and ilmenite. The mafic shells are comprised of very small, anhedral, granular crystals of plagioclase, orthopyroxene, magnetite, ilmenite, amphibole and minor biotite. Orbicule shells number from a few, to >40. A typical multi-shelled orbicule with 11 shells is seen in Fig. 5 and demonstrates the alternating crystal morphologies. Comb layering found near the orbicules has the same type of patterning but is arranged in long, linear, ribbon-like, strips ranging up to 10 m wide and dozens of metres long that contain layers of elongated, budding, oscillatory zoned

* E-mail: durant@geologist.com
DOI: 10.1180/0026461026660073

© 2002 The Mineralogical Society