Abstract  There are many lines of evidence to be evaluated in considering the identity and origin of primary magmas; conclusions reached cannot be valid unless they satisfy the constraints imposed by phase equilibrium experiments. Interpretation of laboratory phase equilibrium experiments is not always unambiguous. Experiments in small crucibles in the presence of water under pressure satisfied many petrologists that batholithic granites involved partial fusion of crustal rocks during the culmination of regional metamorphism. Then, the concept of subducted oceanic lithosphere provided a relatively high-silica source material for magma generation at mantle depths, and dehydration of the sinking slab provided water to lower the melting temperature of overlying mantle peridotite. Batholiths may include material derived from magmas whose genesis was initiated in all three environments. Phase equilibrium data are available to explore the melting products of subducted micaceous sediments and calcareous oozes trapped within basalt. Limestones or siliceous limestones could escape complete dissociation or melting to considerable depths, possibly for long-term storage in the mantle. Phase relationships in the system basalt–andesite–rhyolite–H₂O through the pressure interval from depths where metamorphosed basaltic ocean crust melts, to the near-surface levels where batholiths are emplaced and andesites are erupted, is fundamental for understanding this magmatic system. On balance, the phase equilibrium data do not favor the concept of primary granite or tonalite from mantle or subducted crust. Primary water-undersaturated granite magma is a normal product of partial fusion of the crust, but temperatures of normal regional metamorphism

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are too low to generate tonalite liquids. The water content of large batholithic bodies is probably less than 1.5%. Uprise and crystallization produces water-saturated liquids in the upper regions and margins of magma chambers, for satellite intrusions or eruption. Gravity drives magma and energy upward from subducted oceanic crust, and the final, uppermost expression of the process is represented by the batholiths and attendant volcanoes.

1 INTRODUCTION

The concept of primary magmas has dominated petrogenesis. A primary magma is a liquid derived by partial fusion of a crystalline rock at depth, followed by separation from its source and independent uprise. Petrologists have argued about which magmas were primary, and which igneous rocks were derived from primary magmas by various differentiation processes. The problem is to unravel the history of a rock from its petrography, chemistry and mineralogy. This is not an easy task, especially when one considers that magmas could experience continuous fractionation from source to surface eruption—the other extreme from primary magmas.

I am very fond of a statement by C. E. Wegmann (1963, p. 5): "commonly the notions, concepts and hypotheses control the selection of facts recorded by the observers. They are nets retaining some features as useful, letting pass others as of no immediate interest. The history of geology shows that a conceptual development in one sector is generally followed by a harvest of observations, since many geologists can only see what they are asked to record by their conceptual outfit." It is a fact that interpretation of field data is rarely unambiguous. Most readers have probably shared the rather disconcerting experience of being in a field party where three geologists examining the same outcrop come up with three different interpretations. Their interpretations are guided not only by what they see, but also by their conceptual spectacles, or blinkers. Interpretations of petrography and mineralogy may be guided in the same way.

There are many factors to be evaluated in considering the identity and origin of primary magmas, and there are many lines of evidence including the study of isotopes, rare earth elements, and other trace elements. Conclusions reached from these and other lines of evidence cannot be valid unless they also satisfy the requirements and constraints imposed by phase equilibrium experiments. Laboratory experiments conducted under controlled conditions could be expected to provide unambiguous data relevant to the origin of rocks. For example, a primary magma must