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This Week's Citation Classic®

Yoder H S, Jr. & Tilley C E. Origin of basalt magmas: an experimental study of natural and synthetic rock systems. *J. Petrology* 3:342-532, 1962.
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Natural basalts and eclogites were investigated experimentally at a series of temperatures in the pressure range 1 atm to 40 kb and with water pressures of 1 to 10 kb. The stability regions of the various basalt types and their conversions to eclogite and amphibolite were determined. The effects of pressure on equilibrium thermal divides as well as the effects of oxidation and volatiles on the liquid lines of descent from a common parent were outlined for the most abundant rock type in the crust of the earth. [The *SCI*® indicates that this paper has been cited in over 865 publications.]

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After a series of detailed studies on the stability relations of the principal endmembers of the phases in basalts, it became evident to us that an understanding of the multicomponent system would not be achieved in a reasonable time studying the effect of each component one at a time. This impatience led to a less rigorous approach in which a natural igneous rock, presumed to have been at one time all liquid, could be treated as a single bulk composition in the multicomponent system. From the experiences gained with several of the constituent mineral groups, we considered it appropriate to examine the range of stability conditions of the various natural basalt types and their high-pressure analogues in the new high-pressure and high-temperature equipments that had just been developed at the Geophysical Laboratory.[1,2]

As a result of a vigorous debate on the role of water in metamorphism[3] with Tilley, we became fast friends, and he returned for extended periods to the Geophysical Laboratory as a research associate of the institution for cooperative studies with J.F. Schairer and me. The six-year period following 1954 was the most productive and exciting of my scientific career. Tilley was a walking encyclopedia on the definition and occurrence of natural rocks, a superior petrographer with a photographic memory, and best of all, a kindly, witty gentleman of the old school.

The outline of the paper, preliminary accounts of which had appeared in the Laboratory's annual reports,[4-10] took shape during our visit to Caltech in the fall of 1958 to present jointly a course in petrology. The construction of the basalt tetrahedron[9] and the concept of the thermal divide came to me while preparing lectures. Drafts of the paper were reviewed by Tilley and unresolved disagreements were left with phrases such as "On the other hand,...." Tilley "retired" from the University of Cambridge in 1961, but we continued to collaborate for extended periods at the Geophysical Laboratory until 1967. Much of the "supreme exhilaration of the chase" (Tilley's own words) ebbed with the passing of Schairer on September 26, 1970, and Tilley on January 24, 1973.

No rigorous analysis of the citations to the paper has been made; however, the principal value of the wide-ranging and detailed monograph probably lies in the close integration of experimental studies of both pure and natural systems with the petrography of natural rocks. It brought together more than six years of research, all funded internally. The principles and concepts developed were sufficiently fundamental and of wide application to be of lasting value.

The effects of high pressure (depth) and volatiles that result in phase changes and large shifts of phase relations continue to grow in importance in the new models of magma generation.[11] The basalt tetrahedron provides the intellectual framework within which basalt problems can be defined simply and tested rigorously. The concepts appear to have withstood more detailed and accurate testing during the subsequent 25 years. Nevertheless, the "model" has its limitations: one, for example, the lack of the component K_2O, is now being remedied in the experimental investigation of its expanded analogue, the kalsilite-forsterite-larnite-quartz system.[12]

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5. **Yoder H S, Jr. & Tilley C E.** Natural tholeiite-water system. *Carnegie Inst. Wash. Year Book* 55:169-71, 1956.
6. ———. Basalt magmas. *Carnegie Inst. Wash. Year Book* 56:156-61, 1957.
7. **Yoder H S, Jr.** Effect of water on the melting of silicates. *Carnegie Inst. Wash. Year Book* 57:189-91, 1958.
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10. ———. Derivation of magma types from a primary magma. *Carnegie Inst. Wash. Year Book* 60:106-13, 1961.
11. **Yoder H S, Jr.** *Generation of basaltic magma.* Washington, DC: National Academy of Sciences, 1976. 265 p.
12. ———. Potassium-rich rocks: phase analysis and heteromorphic relations. *J. Petrology* 27, 1986. (In press.)

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