

Thus there should be an unnaturally high probability that a molecule of atmospheric methane containing tritium contains a deuterium atom as well. Such a measurement of the ratio $\text{CH}_3\text{T}:\text{CH}_3\text{DT}$ will require mass separation prior to the application of low-level counting techniques. The ratio of HT:DT in atmospheric hydrogen is much easier to determine since these isomers can be separated by gas chromatography⁶. The answer here will depend not only on the origin of the tritiated hydrogen, but also on whether it can undergo exchange with atmospheric water.

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¹ Bishop, Delafield, Eggleton, Peabody and Taylor, *Symp. Detection and Use of Tritium in the Physical and Biological Sciences*, Vienna, 1961, Paper No. TTS/79.

² *The Effects of Atomic Weapons*, edit. at Los Alamos Scientific Laboratory, Sept. 1950 (U.S. Government Printing Office, Washington, D.C.).

³ Gonsior, B., *Naturwiss.*, **46**, 201 (1959). Begemann, F., and Friedman, I., *Z. Naturforsch.*, **14**, a, 1024 (1959). Bishop, K. F., and Taylor, B. T., *Nature*, **185**, 26 (1960).

⁴ Hagemann, Gray, Machta and Turkevich, *Science*, **132**, 542 (1960).

⁵ Lee, J. K., Musgrave, B., and Rowland, F. S., *J. Chem. Phys.*, **32**, 1266 (1960).

Formation of Pegmatitic Carbonatite in a Syenite-Marble Contact

IMMEDIATELY north of the village of Karacayir, vilayet Sivas, Turkey, a small intrusion of rather coarse-grained syenite occurs in a banded marble formation of unknown age. Here I had occasion to study in some detail a peculiar coarse-grained marble of pegmatitic appearance, containing biotite and apatite. The banded marbles seem to be regionally metamorphosed, on which the thermal metamorphism caused by the intrusion is superimposed. The part of the marble which protrudes into the syenite is changed into a carbonatite-pegmatite. Otherwise the marbles retain their regular banding, which even seems to be accentuated when nearing the contact. Within the aureole of thermal metamorphism small crystals of phlogopite and diopside develop in small amounts on the stratification planes as well as throughout the marble. Near the contact small dikes of syenite-aplite and more-or-less crushed syenite-pegmatite cut through the marbles; the syenite itself contains locally muscovite.

A non-metamorphic fossiliferous impure nummulitic limestone lies unconformably on top of both marble formation and syenite, thereby defining the age of the latter as pre-Eocene. Intra-formational conglomerates are polymixt, containing quartz-pebbles, quartzites, quartzitic schists and acid intrusives.

Next to calcite the pegmatitic carbonatite contains large (up to 1 in. and more) biotite crystals, slender hexagonal prisms of green apatite, and locally small idiomorphic thorianite (ThO_2) crystals. In one place a mass of large idiomorphic allanite crystals has been found, of platy habit, up to 1 in. across. Direct evidence that this carbonatite actually passed through a molten state is not available, as no carbonate-glass was found. Wyllie and Tuttle¹ state

that: "Some carbonate liquids can be quenched to a glass by extremely rapid cooling, but in nature such rapid cooling is unlikely and evidence of melting in rocks will be difficult to find".

The total obliteration of the pre-intrusive structure of the marble, the idiomorphic and coarse-grained habit of its constituent minerals, its obvious permeation with magmatic fluids (addition of thorium, rare earths, phosphorus pentoxide, (Fe,Mg)O, silica and water) indicate a pseudo-liquid condition of this carbonatite mass at the time of the syenite intrusion. This condition is most probably caused by the presence of a liquid phase, a carbonate melt.

According to the same authors¹ the partial melting of carbonates in the presence of water vapour starts at temperatures as low as 650° C., and at pressures reached at relatively high levels in Earth's crust. This temperature is almost certainly exceeded during the intrusion of a syenitic magma. In another publication Wyllie and Tuttle² state that: "Although calcite is generally the dominant mineral in carbonatites . . . apatite and mica are constant accessories". The presence of radioactive and rare-earth minerals (thorianite and allanite) in the carbonatite mass shows its close affinity to 'normal' intrusive carbonatites. It is believed, in the light of the results obtained by Wyllie and Tuttle^{1,2}, that pressure-temperature conditions in this contact provoked the (partial) liquefaction of the marble, which recrystallized on cooling as a pegmatitic mass of carbonatite composition. The importance of this example lies in the fact that here a carbonatite, associated as usual with alkaline intrusives, is still indisputably recognizable as the direct continuation of a sedimentary marble. Though I certainly do not claim definitely that carbonatites must be formed this way, it shows at least that they may.

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¹ Wyllie, P. J., and Tuttle, O. F., *Amer. Min.*, **44**, 458 (1959).

² Wyllie, P. J., and Tuttle, O. F., *Nature*, **183**, 770 (1959).

METALLURGY

Embrittlement of Grain Boundaries by Equilibrium Segregation

EQUILIBRIUM segregation of impurities or solute elements has frequently been suggested as a cause of grain boundary embrittlement in metals and metallic compounds, but the evidence has been largely indirect. Even if the existence of grain boundary segregation be granted in specific instances, the manner in which such segregation might give rise to embrittlement has remained wholly speculative. It is the purpose of this communication to report that in a large number of cases where boundary segregation is established, suspected, or possible, a significant hardening of the grain boundary region relative to that of the interior of the grain is observed by microhardness measurements.

A typical result is shown in Fig. 1 for a high-purity iron sample treated by Ainslie *et al.*¹ in a sulphur-bearing atmosphere and demonstrated by them with tracer techniques to contain sulphur absorbed in grain boundary regions. This case appears to be the most firmly established instance of equilibrium grain boundary segregation on record. Tests on a com-