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Ilmenite and plagioclase crystals in the vesicles of grey basalt from Deer Park, Victoria, Australia

EXTENSIVE flows of basic lavas erupted in Victoria during late Tertiary and Pleistocene times. Although the mineralogy of the flows is reasonably well documented (e.g. Coulson, 1938; Spencer-Jones, 1967; Reynolds, 1972) very few studies have focused on the mineralogy of the high-temperature assemblages in vesicles. Birch (1979) recorded small crystals of titan-phlogopite in the vesicles of basalt from Greenvale, Victoria. Birch (1980) also reported a suite of vesicle minerals in an olivine leucitite from Cosgrove, Victoria and several minerals including ilmenite in the vesicles of an alkali basalt from Portland. An iddingsite-labradorite basalt flow is exposed in a quarry at Deer Park near Melbourne. The lower part of the flow is non-vesicular and contains two types of expanding and non-expanding amygdaloidal chlorite-like clay minerals that have developed as a result of deuteric alteration of olivine and glass (Cole and Lancucki, 1975). The upper part of the flow is a vesicular grey basalt and investigation revealed the presence of an ilmenite-plagioclase assemblage described here.

Experimental. In rock samples obtained for earlier work it was noticed that some vesicles of the grey basalt contained colourless tabular crystals and bladed crystals having a bright metallic green or blue lustre (fig. 1). These crystals were partially or completely coated with a white material. The crystals were removed from the vesicles, cleaned with dilute HCl, and X-rayed using a Gandolfi camera. The crystals were then examined by a scanning electron microscope (Jeol U3 SEM) and analysed by wavelength-dispersive electron probe microanalysis (EPM) on a Jeol JXA 50A microprobe. The standards for EPM were TiO_2, Fe_2O_3, pure Mn and adularia for Ti, Fe, Mn, and K respectively, wollastonite for Si and Ca, and $MgAl_2O_4$ for Mg and Al. Opaques in the thin section of the rock were examined by the EDAX (energy dispersive analysis of X-rays) attachment to the SEM.

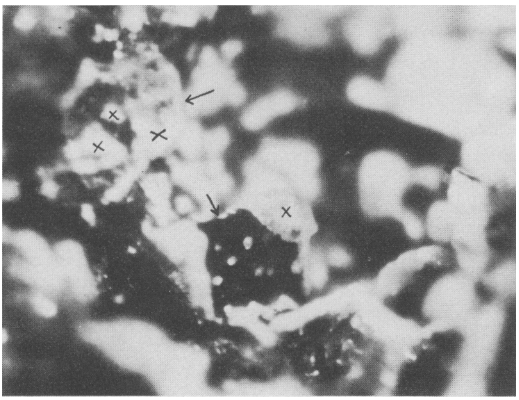

FIG. 1. Photograph of a vesicle showing ilmenite crystals (arrows) partially or completely coated with dolomite (crosses). The plagioclase crystals are not visible due to the small depth of focus. Magnification: 40 ×.

Results and discussion. X-ray diffraction studies identified the white coating material as dolomite, the bladed crystals with blue-green lustre as ilmenite, and the colourless crystals gave the general pattern of the intermediate members of the plagioclase feldspars. Scanning electron microscopy showed that the ilmenite and plagioclase crystals carried some deposits even after acid cleaning; the former seemed to have been slightly pitted by the acid with a small Si-rich grain sitting at the centre of the pit. The dark lath-like rods removed from the thin rock section appeared to be of the kind identified as ilmenite in the vesicles. Although this was true for most of the rods, some others were shown by EDAX to contain large amounts of S and Fe with negligible Ti, consistent with some iron sulphide composition. Therefore, not all rod-like material in the thin sections of this rock can be assumed to be ilmenite.

Electron probe analyses taken from smooth parts of flat-lying ilmenite and plagioclase crystals gave the following representative compositions: Ilmenite: SiO_2, 7.14; TiO_2, 48.25; Al_2O_3, 0.61; FeO, 41.85; MnO, 0.22; MgO, 3.15; total 101.22%. Plagioclase: SiO_2, 60.58; Al_2O_3, 23.03; Fe_2O_3, 1.08; MgO, 0.97; CaO, 8.38; Na_2O, 5.10; K_2O, 0.31; total 99.45%.

Except for a higher silica content, presumably impurities, the analyses of ilmenite agree reasonably well with some of those of Deer *et al.* (1967), while ilmenite from Portland, Victoria (Birch 1982) was richer in Ti and Fe. The structural formula of Deer Park ilmenite, based on six oxygens, is $TiAlFe^{2+}_{1.86}Mn_{0.01}Mg_{0.24}O_{6.00}$, which shows a slightly larger substitution of Mg for Fe^{2+} than most of those reported by the above authors. The composition of the plagioclase from the above analysis ($Ab_{48}An_{50}Or_2$) falls on the boundary of andesine–labradorite. However, the MgO percentage of this analysis is larger than those of andesine and labradorite reported by Deer *et al.* (1963), who pointed out that Mg could substitute for Ca in the anorthite molecule. The larger MgO percentages for ilmenite and plagioclase of the Deer Park grey basalt is consistent with the analysis of the rock itself, which indicates 9.70 MgO, 7.80 CaO, 6.80 FeO, and 3.42% Fe_2O_3.

The vesicles form early in the cooling history of the lava flow as a result of the release of volatiles, which assist the movement of residual liquids and facilitate crystallization of minerals in the vesicles. This feature was less extensive in the Deer Park basalt than in the Portland alkali basalt and in the Cosgrove leucitite, since vesicle formation and mineral crystallization was less developed in the former. The differences in mineral assemblages and in vesicularity of the rocks reflect the differences in the composition of the original magma, the residual liquids, and the volatiles.

The equilibrium diagram of plagioclase feldspars indicates a crystallization temperature of 1285 °C for the andesine–labradorite ($Ab_{48}An_{50}Or_2$) from Deer Park. This temperature, however, would be applicable to a volatile-free system and, for the vesicle minerals of the grey basalt, a temperature range of 700 to 900 °C, similar to that suggested for Cosgrove leucitite (Birch, 1980), is probably more reasonable.

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CSIRO Division of Building Research, Melbourne, Victoria, Australia

A. SHAYAN
C. J. LANCUCKI

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The composition of sphalerites from Ishiagu, E. Nigeria

A NUMBER of sphalerite samples have been collected from Quarries 1 and 2 (fig. 1) at Ishiagu, about 80 km SSE of Enugu. The sphalerite occurs with galena and minor pyrite in a gangue of siderite and quartz, in steeply dipping veins which follow fault zones trending approximately N40° W. Previous reconnaissance work on the deposits (Cotsworth, 1949; McConnell, 1949; Bogue, 1952; and Farrington, 1952) did not involve any detailed mineralogy. The purpose of this note is to present new analyses for both major and minor elements in the sphalerite, and to discuss possible indications of the temperature of formation.

Geology and physiography. The geology of the Ishiagu region is shown in fig. 1. The geology of the area, which lies between 30 and 100 m o.d. and is covered by tropical rainforest, is dominated by the Asu River Formation, which consists of carbonaceous shale with sandstone lenses of Albian age. The Ezeaku Shale Formation (Turonian) has a basal sandstone unit which lies unconformably above the Asu River Formation. The former now occurs in the NW and SE of the area, on the limbs of a gentle anticline which trends NE. An alkaline dolerite sill is intruded into the Asu River Formation (Ezepue, 1979) and forms the principal host to the mineral veins. Two sets of steeply dipping faults cut the sill, striking at around N30° W and N50° E. Only the former carries mineralization.

Composition of the sphalerites. Five samples were