LEVYNE FROM DÖZEN (OKI ISLANDS), JAPAN

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ABSTRACT

Levyne, chabazite and other zeolites occur in amygdules of a Pliocene trachybasalt lava near Kuniga, Nishi-no-shima, Döz en (Oki Islands). Levyne forms aggregates of thick tabular crystals with or without thomsonite and cowlesite. Wet-chemical analyses yielded the empirical formulae \( (Na)_a.(K)_{0.00} (Ca)_{0.56}Al_{2.00}Si_{4.75}O_{12} \cdot 7.8H_2O \cdot (Z=9) \) for levyne; and \( (Na)_a.(K)_{0.09}Ca_{0.85}Fe^{3+}Al_{1.5}Si_{4.8}O_{12} \cdot 6.3H_2O \cdot (Z=6) \) for chabazite. The levyne has \( n_a \) 1.497, \( n_b \) 1.494, hexagonal parameters \( a \) 13.338, \( c \) 23.004\AA, specific gravity 2.04.

HOST ROCK

An amygdaloidal, zeolite-bearing trachybasalt flow crops out at a road-cut about 750 m northwest of Kuniga tunnel, Nishi-no-shima, Döz en, Oki Islands (Fig. 1). Döz en (Oki Islands) is a part of remnants of a Pliocene volcano composed of somma, caldera, and a central cone (Tiba 1975). The lava pile of the somma reaches 350 m in maximum thickness, though individual lavas are usually 1-2 m thick or less. The trachybasalt lava which is the host of the amygdules is 5 m thick and is in the lower part of the somma lava pile.

The trachybasalt contains abundant megascopic plagioclase phenocrysts in a dark grey, dense matrix and has cavities and amygdules of various sizes and shapes. Plagioclase occurs as euhedral prismatic or tabular crystals, generally 1 to 2 mm and occasionally up to 5 mm in size, which are polysynthetically twinned and which are distinctly zoned in their outer part. Clinopyroxene grains are short prismatic, average about 0.6 mm long, and are rarely twinned. Euhedral olivine has been entirely replaced by aggregates of pale straw-yellow or light green fibres rimmed by magnetite ribbons. Magnetite occurs as euhedral grains 0.2-0.4 mm across. The fine-grained, dense groundmass consists mainly of plagioclase laths, euhedral to subhedral clinopyroxene grains, irregular-shaped magnetite granules, and ilmenite spicules with subordinate hematite.

Chemical analysis and CIPW norms of the trachybasalt are given in Table 1. The rock has a high TiO\(_2\) content and high Fe\(_2\)O\(_3\)/FeO and K\(_2\)O/(Na\(_2\)O+K\(_2\)O) ratios. The rock is a member of moderately potassic lineage (alkali olivine basalt—trachybasalt—tristanite—K-rich trachyte defined by Coombs & Wilkinson (1969). The small amount of normative quartz
is interpreted to be the result of alteration of olivine.

**Amygdules**

The amygdules are generally oval and 1 to 10 cm across (Figs. 2). Some horizontally flattened, irregular-shaped amygdules exceed 10 cm in length and show a roughly parallel arrangement. Amygdules stained by a light yellow substance are common. Several associations of amygdales minerals have been recognized; their decreasing frequency of appearance is: (1) chlorite+thomsonite+chabazite; (2) chlorite+levyne; (3) chlorite+thomsonite+chabazite; (4) chlorite+calcite; (5) chlorite+thomsonite+chabazite+calcite; (6) chlorite+cowsesite+levyne; (7) chlorite+calcite+phillipsite+chabazite; (8) chlorite+thomsonite+levyne; (9) chlorite+cowsesite.

**LEVYNE**

The levyne from Dōzen occurs either as a monomineralic phase in amygdules, or in association with cowsesite or thomsonite only. The levyne is present as transparent, thick tabular hexagonal crystals (Fig. 3) up to 8 mm in diameter and 1 mm thick. The crystals occur on a thin film composed of aggregates of fibrous dark green chlorite which rims the amygdules. Some levyne is found as isolated crystals, but most of the tabular crystals form boxworks which completely fill the amygdules (Fig. 2). Much of the levyne is associated with cowsesite or thom-

![Fig. 1. The locality of zeolite-bearing trachybasalt.](image)

sonite, and in these cases the levyne crystals are present sporadically on white minute cowsesite scales which grew inward on the chlorite film or on mammillary aggregates of thomsonite. Both cowsesite and thomsonite are always older than levyne. Levyne is never in direct contact with chabazite, phillipsite or calcite. Scanning electron microscope and X-ray powder-diffraction studies show that other zeolites are not associated with levyne crystals. Thus, the Dōzen occurrence differs from those at Beech Creek (Sheppard et al. 1974; White 1975), Sardinia (Passaglia & Galli 1974), Deccan traps (Chatterjee 1971) and Kawajiri (Mizota et al. 1974), all of which have erionite or offretite intergrown with levyne. The occurrence of levyne without associated chabazite in this case also distinguishes Dōzen levyne from those from County Antrim (Walker 1951, 1960a), Iceland (Walker 1960b) and Sardinia (Passaglia & Galli 1974).

![Fig. 2. Thin section of levyne. Crossed polars. Scale bar is 1 mm.](image)

Table 1. Chemical analysis and CIPW norms of zeolite-bearing trachybasalt (NSM-M20523)

<table>
<thead>
<tr>
<th>Element</th>
<th>wt%</th>
<th>CIPW norms wt%</th>
</tr>
</thead>
<tbody>
<tr>
<td>SiO₂</td>
<td>47.44</td>
<td>Q 0.44</td>
</tr>
<tr>
<td>TiO₂</td>
<td>2.87</td>
<td>or 17.14</td>
</tr>
<tr>
<td>Al₂O₃</td>
<td>17.22</td>
<td>ab 23.59</td>
</tr>
<tr>
<td>Fe₂O₃</td>
<td>4.59</td>
<td>an 25.89</td>
</tr>
<tr>
<td>FeO</td>
<td>4.96</td>
<td>wo 6.04</td>
</tr>
<tr>
<td>MnO</td>
<td>0.16</td>
<td>di 4.83</td>
</tr>
<tr>
<td>MgO</td>
<td>3.34</td>
<td>fe 0.51</td>
</tr>
<tr>
<td>CaO</td>
<td>8.88</td>
<td>hy 3.48</td>
</tr>
<tr>
<td>Na₂O</td>
<td>2.79</td>
<td>fs 0.37</td>
</tr>
<tr>
<td>K₂O</td>
<td>2.90</td>
<td>mt 6.64</td>
</tr>
<tr>
<td>H₂O</td>
<td>2.46</td>
<td>ti 5.44</td>
</tr>
<tr>
<td>H₂O⁻</td>
<td>1.76</td>
<td>ap 0.94</td>
</tr>
<tr>
<td>P₂O₅</td>
<td>0.39</td>
<td>cc 0.41</td>
</tr>
<tr>
<td>CO₂</td>
<td>0.18</td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>99.94</strong></td>
<td></td>
</tr>
</tbody>
</table>
The levyne is uniaxial negative with $n_\omega$ 1.497 and $n_e$ 1.494 (both ±0.002). Penetration twins are commonly observed in thin sections. All the diffraction peaks of the Dözen levyne are satisfactorily indexed in terms of a unit cell with $a = 13.338$, $c = 23.004\AA$, space group $R3m$.

X-ray powder patterns of levynes and chabazites from several amygdules were checked prior to the preparation of material for chemical analyses. No significant variations were observed. Chemical analyses of hand-picked levyne and chabazite, with purity confirmed by microscopy and X-ray diffractometer studies are given in Table 2. Their $\text{SiO}_2$ contents are rather low, whereas $\text{Al}_2\text{O}_3$ contents are high. Levyne has a $\text{H}_2\text{O}$ deficiency and chabazite has excess $\text{H}_2\text{O}$ compared with their theoretical formulas.

Although the mole ratio $\text{Al}_2\text{O}_3/(\text{CaO}+\text{Na}_2\text{O}+\text{K}_2\text{O})$ for any zeolite (devoid of $\text{Fe}_2\text{O}_3$ and $\text{Ti}_2\text{O}_3$) should be unity, this ratio for the levyne and chabazite is 0.97 and 1.07, respectively. The $\text{Si}/\text{Al}$ ratio for levyne is 1.64 and for chabazite, 1.80. The $(\text{Na}+\text{K})/(\text{Ca}+\text{Na}+\text{K})$ ratios for levyne and chabazite are 0.30 and 0.32, respectively. The levyne is more aluminous and calcic and less potassic than the associated chabazite.

**Discussion**

Atomic ratios calculated on an anhydrous basis of $O=12$ (or $\text{Si}+\text{Al}=6$) obtained from the known reliable analyses of levynes are given in Table 3. As can be seen in the table, the $\text{Si}/\text{Al}$ ratios range from 2.21 to 1.59. Assuming three substitution couples: $\text{CaAl}+\text{NaSi}$, $\text{Ca}=2\text{Na}$, and $\text{Na}=\text{K}$, the sum of $\text{Ca}$, $\text{Na}$, and $\text{K}$ must range from 0.99 to 1.17 in accordance with the variation of $\text{Si}/\text{Al}$ ratio stated above. Levyne analyses...
conform fairly well with this assumption. On the other hand, if only two substitution couples, CaAl\leftrightarrow NaSi and Na\leftrightarrow K, are allowed (Feoktistov et al. 1971), the sum of Ca+Mg+Na+K must be 1 on the anhydrous basis of O=12, independent of Si/Al variation. However, significant deviations from the sum of 1 are present, especially in levynes with high alkali contents. Thus, compositional variation of levyne is explained better by the combination of the three substitution couples mentioned above. The H₂O content is highly variable from 4.62 to 5.80 and considerably lower than the theoretical value 6 in all cases. It is not known whether such H₂O deficiencies are structural or result from inadequate sample preparation. From the data available, the ideal formula of levyne may be expressed as (CaNa₇)Al₅Si₉O₂₆+6H₂O (with Na < Ca). Levyne in silica-poor rocks such as olivine basalt from Iceland and trachybasalt from Dōzen have low Si/Al ratios, but the ratio is high in levynes in silica-rich rocks such as andesite from Sardinia.

Figure 5 gives the relationship between refractive indices and (Na₉+K₉)/(Ca+Na₉+K₉) ratios in levynes. The substitution of Na₉ or K₉ for Ca lowers the refractive indices of the mineral.

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REFERENCES


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