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Occurrence of Alkaline Lamprophyre Dyke from Schirmacher Range, Dronning Maud Land, East Antarctica

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Abstract

Alkaline basic dyke with low K_2O/Na_2O ratio (<1), poor TiO_2, high CO_2 and H_2O content, dominant carbonate phase and absence of feldspar phenocrysts corresponding to monchiquite variety of alkaline lamprophyrc is being reported from Schirmacher Range of Central Dronning Maud Land, East Antarctica. Zoned clinopyroxene (augite, diopside), zeolite, altered plagioclase, biotite, nepheline and glass constitute the dyke which has associated marginal brecciation along with xenoliths of country rocks.

Introduction

The poly metamorphosed and multideformed Precambrian rock sequence of Schirmacher Range (Fig.l) in the Central Dronning Maud Land of East Antarctica exhibit varied assemblage of mafic intrusions (Kaul *et al.,* 1985). Singh *et al.,* (1988) have described basic and ultrabasic rocks including dolerite, nodular basalt, olivine norite, mela-syenite etc. from Schirmacher and the nunataks lying south of it. They have identified lamprophyres of shoshonitic affinity from Pevikhornet (70°58'S : 11°52'E) and Sonstebynuten (70°55'S : 12°15'E) nunataks. Shoshonites have also been identified by Wand *et al.,* (1991) from Schirmacher Oasis. Elsewhere, alkaline lamprophyre dykes (AL) are known to occur associated with high grade gneisses in Vestfold hills, Prince Elizabeth Land (Delor & Rock 1991), Sor Rondane Mountain (Van Autenboer 1969) and Wohlthat massif (Tingey, 1991) in East Antarctica.

The present report is to record lamprophyres of monchiquite variety from Schirmacher Range. Significance of lamprophyres as rocks with their source at great depth need not be overemphasised.

Geological Setting

Schirmacher Range is an ice free oasis of low lying exposures spread over an area of around 35 sq km off Princess Astrid Coast in the Central Dronning Maud Land of East Antarctica. The area exposes high grade polymetamorphosed ortho- and paragneisses including biotite-garnet gneiss, pyroxene granulites, calc-gneiss, khondalite along with migmatites and augen gneisses (Singh 1986, Sengupta 1986, 1988). The rocks are intruded by pegmatites, quartzofeldspathic veins, dolerites and basaltic dykes, conforming well with

GENERALISED GEOLOGICAL MAP OF SCHIRMACHER RANGE,
EAST ANTARCTICA (After Singh 1986)

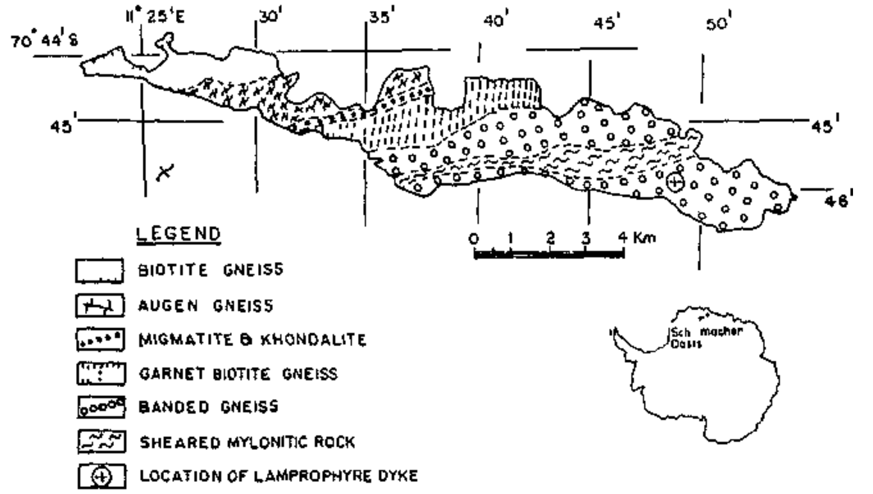

Fig. 1. Generalised geological map of Schimacher Range, Central Dronning Maud Land, East Antarctica with inset of Antarctica.

the regional geological framework of the main mountain chain of Wohlthat massif exposed south of Schirmacher (Ravich & Kamenev 1975, Ravindra *et al*, 1991)

The rocks have a regional foliation trending ENE-WSW with moderate to steep dips towards SSE. The host rocks (gneisses) are highly deformed with four phases of folding and two imprints of migmatisation (Sengupta 1988) The two earlier episodes of folding exhibit co-axial relationship while the subsequent phase is represented by N-S trending, gently plunging subvertica! folds The last generation of folds are asymmetrical with subhorizontal plunge & moderately dipping axial planes The unmetamorphosed dolentes and ultrabasic dykes intruding the gneisses of Schirmacher have a tholentic composition (Singh *et al.* , op. cit.) Kaiser and Wand (1985) assign Upper Carboniferous/Early Permian (?) age to the older group of dykes and Jurassic/Cretaceous age to the younger dykes by K-Ar dating. Verma *et al,* (1987) have worked out an age between 97±3 and 178 ±10 Ma for some of these dykes.

The alkaline basalt dykes contain mainly olivine and augite set in a groundmass containing microhtes of pyroxene and plagioclase feldspar The late basic intrusives in the area have a distinct alkaline affinity and are more sodic in nature.

The present AL occurs in the eastern part of Schirmacher Range (Fig. 1) where it is found intruding the gneisses at low angles to the regional foliation. The dyke, trending NE-SW, is traceable over a length of about 5 m with an average width of 1 m (Fig 2). A pegmatite vein is exposed along one of the margins of the dyke. The margins ot the dyke are chilled and marginal brecciation is displayed. The field appearance is hypermelanocratic and aphanitic

Fig. 2. Field photograph of the Lamprophyre dyke.

with discernible brown mica. The rock shows carbonate ocelli and glass on microscopic scale (Fig.3). The dyke contains clasts of country rock varying in size from a few mm to 3 cm x 2 cm in dimension (Fig.4).

Petrography

Under microscope, the rock is fine grained in nature and depicts porphyritic to glomero-porphyritic texture. The phenocrysts are made up essentially of ferromagnesian minerals, an important characteristic of lamprophyres (Rock 1977). The porphyritic nature is highlighted by presence of hexagonal and pseudohexagonal clinopyroxenes showing a panidiomorphic habit (Fig.5a, b). The clinopyroxenes show characteristic zoning. The phenocrysts include augite, plates of diopside, biotite, euhedral olivine and brown hornblende. Laths showing zoning and pleochroism may partly be clinopyroxenes and partly amphiboles, indicating alteration. Biotite in some of the sections is present as large crystals surrounded by fine grained aggregate of felsic groundmass. At some places, it shows alteration to vermiculite and/or chlorite along rims forming halos (Fig.5d). The interstitial minerals are mainly carbonates, altered plagioclase (?), nepheline, glass and opaques. Carbonate ocelli (containing mainly zeolites) are very prominent (Fig.5c). The products of alteration are sericite, actinolite, tremolite and some opaques.

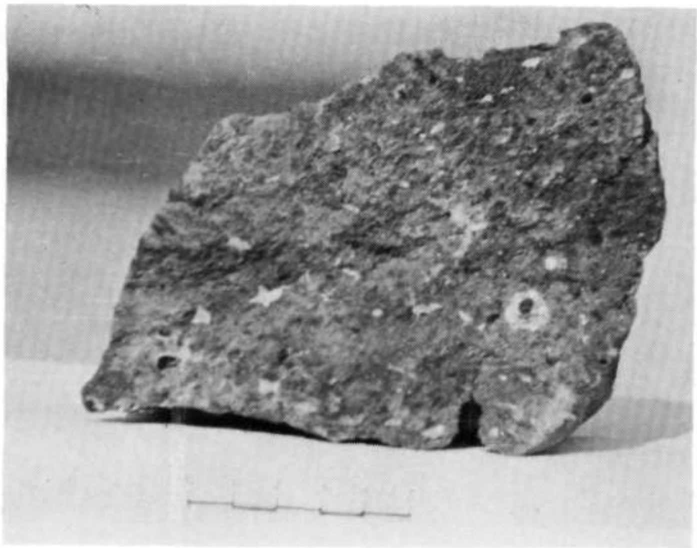

Fig. 3. Lamprophyre sample showing carbonate ocelli and glass.

Fig. 4. Lamprophyre sample showing xenoliths of country rocks.

Discussion

The major oxide geochemistry of AL from Schirmacher (Table 1) compares well with the chemical screen given for lamprophyres of alkaline variety, especially that of

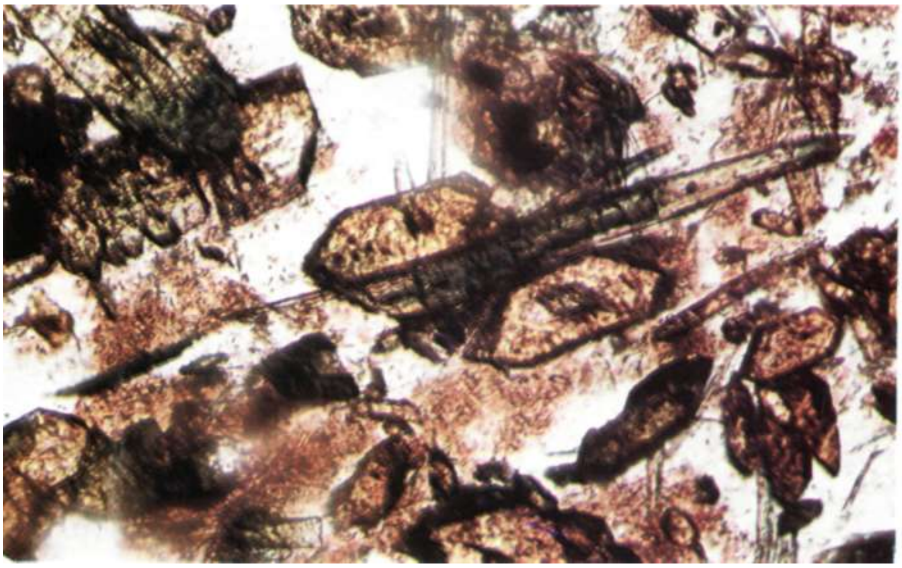

Fig. 5a. Photomicrograph showing typical pamdiomorphic texture depicted by zoned clinopyroxenes set in a groundmass rich in feldspars (O.L., 50x).

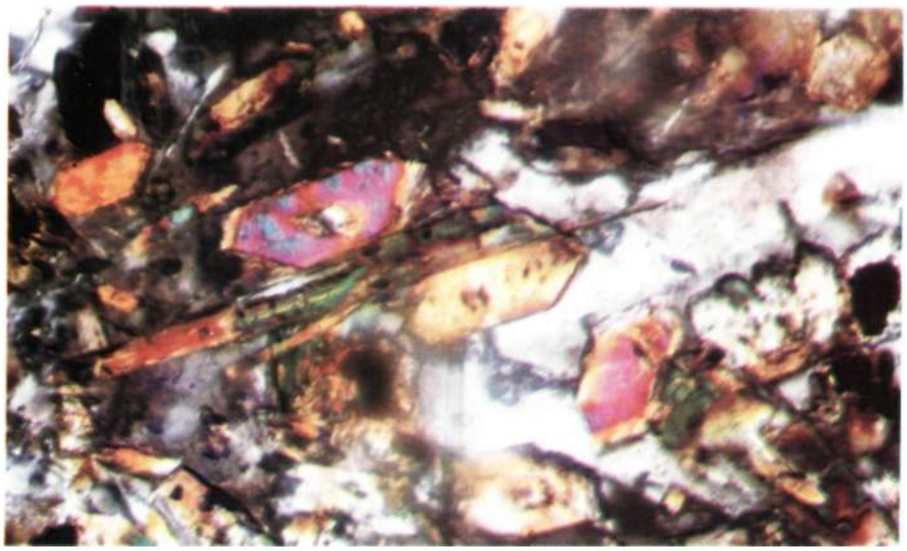

Fig. 5b. Same view as above, under crossed Nicols.

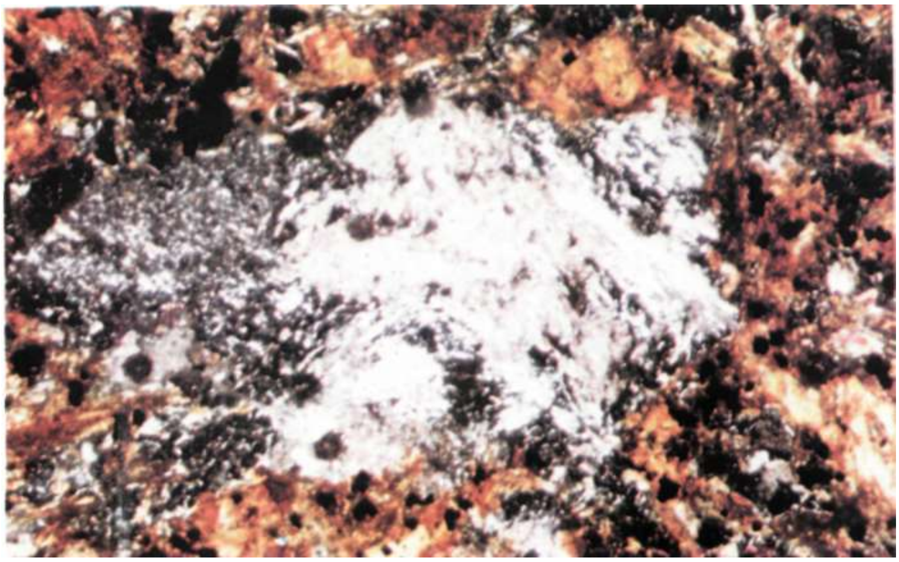

Fig. 5c. Photomicrograph showing carbonate ocelli surrounded by mafic aggregate (C.N., 50x).

Fig. *5d. Photomicrograph showing alteration of biotite megacryst along the rim (C.N., 50x).*

Table 1: Whole-rock Analyses of Schirmacher Lamprophyres

Smpl.No.	SV-1	SV-2	SV-3	SV-4	SV-5	AL*	MONC**
SiO_2	39.05	41.79	39.94	37.98	40.49	42.50	41.06
TiO_2	0.23	0.22	0.24	0.29	0.24	2.90	2.63
Al_2O_3	13.79	15.34	13.10	15.15	14.21	13.39	13.20
Fe_2O_3	6.99	7.17	7.12	7.48	7.29	—	4.39
FeO	5.65	6.06	7.90	6.64	6.81	—	7.16
FeO^t	11.94	21.51	14.3|	13.37	13.37	12.00	—
MnO	0.17	0.20	0.22	0.21	0.20	0.20	—
MgO	8.51	7.22	10.52	8.31	8.29	7.10	8.88
CaO	10.40	10.00	7.75	11.95	11.05	10.30	11.15
Na_2O	2,57	3.75	2.46	3.86	3.43	3.00	3.25
K_2O	1.45	2.60	2.60	2.69	2.51	2.00	1.99
P_2O_5	0.60	0.40	0.70	0.45	0.35	0.74	0.84
H_2O^+	4.89	2.61	3.86	2.60	2.87	—	—
H_2O^-	2.20	0.08	1.97	0.11	0.15	—	—
CO_2	3.42	3.18	1.54	2.56	2.40	—	2.13
CIPW Norms$^+$							
Or	9.66	16.36	16.74	0.00	5.13	—	12.00
ab	8.22	1.91	6.17	0.00	0.00	—	0.00
an	24.59	18.47	18.53	18.38	16.96	—	21.90
le	0.00	0.00	0.00	11.30	8.33	—	2.60
nc	8.83	17.26	8.93	18.85	16.70	—	8.80
di	23.17	25.21	14.70	21.43	31.08	—	18.20
ol	12.85	9.07	22.19	13.00	10.00	—	13.30
mt	11.42	11.07	11.24	11.56	11.23	—	12.40
il	0.50	0.45	0.50	0.59	0.49	—	4.90
ap	1.50	0.99	1.76	1.11	0.86	—	5.90
Cs	0.00	0.00	0.00	4.59	0.00	—	—
Mg/ (Mg+Fe^2)	72.80	68.00	70.33	69.03	68.44	67.27	—
Di	26.10	35.53	31.84	30.15	30.16	—	—
(Na+K)/Al	0.42	0.59	0.52	0.58	0.58	0.51	—
K/(Na+K)	27.00	31.36	41.02	28.08	32.45	30.45	–

* Analytical data from Delor & Rock (1991).

** Analytical data from Rock (1977).

+ Analyses recalculated to 100% free of volatiles.

Di Thornton & Tuttle differentiation index.

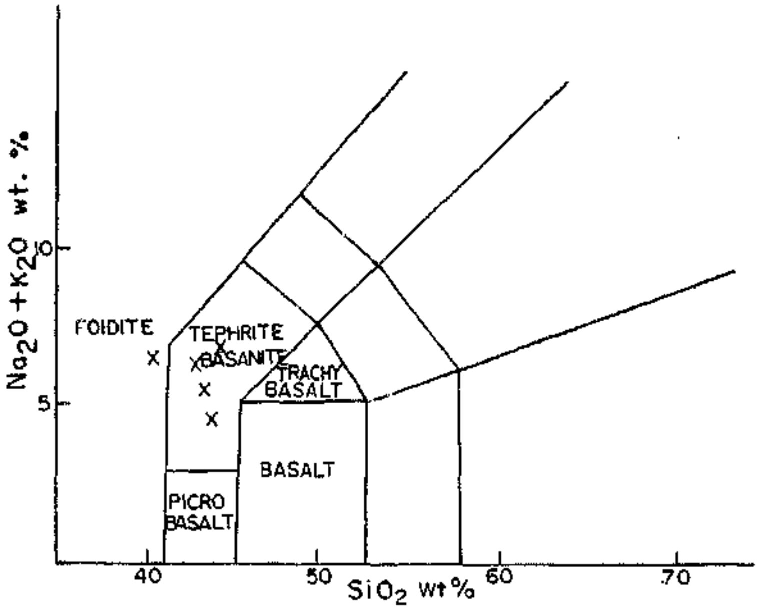

Fig. 6. Total Alkali-Silica plot after Le Bas et al., (1986) showing position of Schirmacher samples. Analyses from Table-1.

monchiquite, except for a very low TiO_2 content. The rock is characteristically high in volatile content and reasonably enriched in alkalies (5%), thereby showing a close correlation to alkaline ultrabasic composition. Nepheline is very prominent in CIPW norms while leucite is formed in two of the sections (SV-4 & SV-5). The rock shows atomic ratio of (Na+K)/Al in the range of 0.42 to 0.59 while that of K/(Na+K) varies between 27 and 41. The Mg number is between 67 and 73 which indicates almost a primary Mg range. When plotted on Total Alkali-Silica diagram "TAS" (Le Bas *et al.,* 1986) the rocks fall in basanite-foidite field (Fig.6). In the K_2O-SiO_2 discrimination diagram of Rock (1987) the plots fall in the AL field (Fig. 7). However, some overlapping with calc-alkaline lamprophyres is noticed. The Al_2O_3-MgO-CaO discrimination diagram after Rock, 1987 (Fig.8) drawing domains between AL and ultramafic lamprophyres, shows the localisation of Schirmacher lamprophyres within the field of AL. Figure 9 illustrating discrimination between shoshonites and alkaline lamprophyres (Manson 1967) shows comparative placement of lamprophyres from Pevikhomet and Sonstebynuten nunataks and those of Schirmacher. While the former fall in the Shbshonitic field, the latter concentrate in alkaline domain. The high volatile content of these rocks distinguishes the lamprophyres from the fields of other igneous rocks. The plot of CO_2-H_2O in Fig. 10 confirms this.

The REE distribution in alkaline lamprophyres (Table 2) shows a moderate concentration of rare earths (102 to 132 ppm). The chondrite normalised REE pattern (Fig. 11) indicates LREE enrichment and subequal amount of middle REE. The (La/Yb) is between 14 to 28 indicating fractionation from primary magma during crystallisation.

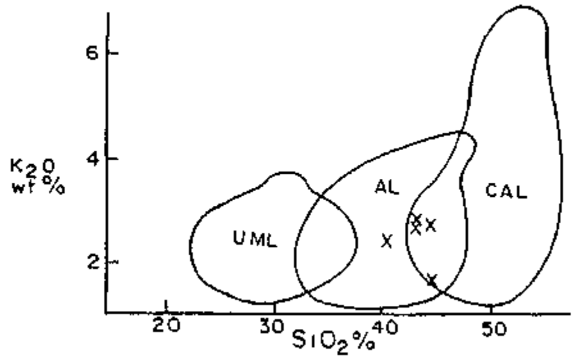

Fig. 7. K_2O-SiO_2 discrimination diagram after Rock (1987)

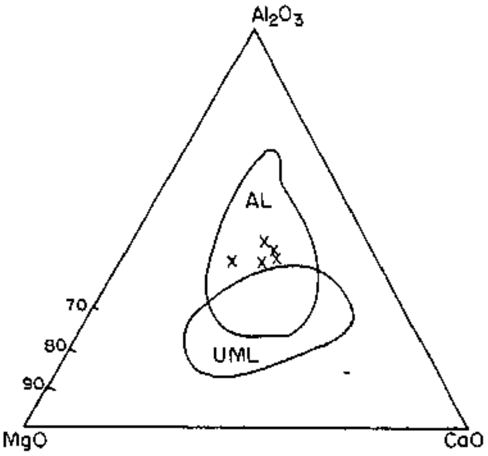

Fig. 8. Al_2O_3-MgO-CaO discrimination diagram after Rock (1987)

Tabic 2: REE Data of Alkaline Lamprophyres of Schirmacher Oasis

Smpl No	SV-1	SV-2	SV-3	SV-4	SV-5
La	27 50	30 68	24 86	29 62	30 04
Ce	27 90	37 20	28 83	40 92	40 92
Pr	7 25	8 34	8 34	1142	8 78
Nd	19 15	23 99	20 20	26 94	25 89
Sm	5 73	6 84	6 66	7 74	7 58
Eu	1 18	135	140	1 71	1 61
Gd	4 41	4 53	616	5 92	4 99
Tb	1 67	177	187	187	1 82
Dy	3 13	3 20	4 25	3 32	3 20
Ho	0 86	0 89	108	0 98	0 86
Er	1 93	2 08	2 64	2 12	2 04
Tm	0 57	0 58	0 76	0 83	0 49
Yb	101	0 92	120	0 80	0 72
Lu	044	0 40	0 70	0 55	0 34
Y	10 93	1164	17 09	11 17	10 93

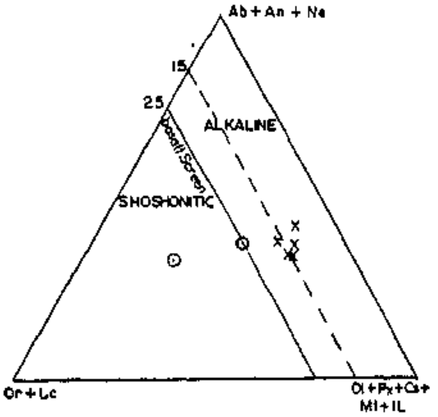

Fig. 9. Discrimination diagram after Manson (1967) modified by Rock (1977).

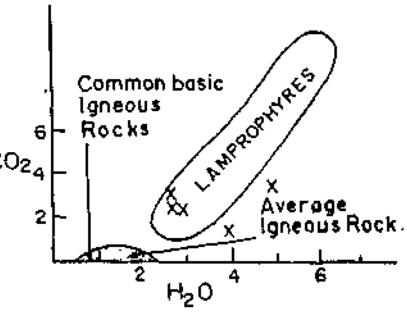

Fig. 10. CO_2-H_2O discrimination diagram after Rock (1987).

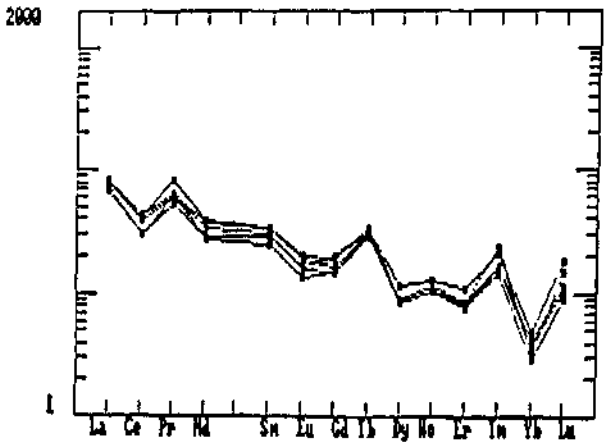

Fig. 11.. REE distribution pattern of alkaline lamprophyres from Schinnacher (after Taylor and McLennan, 1985).

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