Acta Mineralogica-Petrographica, Szeged, XXXV, 47–52, 1994

A STABLE ISOTOPE STUDY ON CRETACEOUS MAGMATIC INFLUENCES IN THE TRANSDANUBIAN MID-MOUNTAINS

A. DEMÉNY*

Laboratory for Geochemical Research, Hungarian Academy of Sciences

M. KÁZMÉR**

Department of Paleontology, Eötvös Loránd University,

ABSTRACT

Results of earlier stable isotope studies on lamprophyre-carbonatite bodies and red calcite dykes in the Transdanubian Mid-Mountains are summarized in this paper. Their genetics have similarities in that they were formed during the Cretaceous and that magmatic fluids presumably played a significant role in their formations. A tentative model is proposed in which magmatism and magmatic fluid circulations would appear in the Transdanubian Mid-Mountains in different forms depending on spatial and/or temporal positions; i.e. emplacement of mantle-derived lamprophyre-carbonatite bodies during the Middle-Upper Cretaceous that induced carbonate vein formations, and formation of red calcite dykes of Aptian to Campanian ages that show magmatic $\delta^{13}C$ and δD signitures and can be related to movements of deep-seated igneous fluids.

INTRODUCTION

This paper presents a summary of conclusions of earlier stable isotope studies (DEMÉNY 1992, 1993, DEMÉNY *et al.* 1994) on lamprophyre-carbonatite bodies and red calcite dykes of the Transdanubian Mid-Mountains that have two common features: their ages range from Middle to Upper Cretaceous (HORVÁTH *et al.* 1983, EMBEY-ISZTIN *et. al.* 1989; KUBOVICS 1985, KUBOVICS *et al.* 1989; HAAS *et al.* 1984) and their genetics are proved or thought be related to magmatic processes (see later). The presumed genetic links, the similar ages and the spatial proximity lead us to suggest a tentative model of movements of mantle-derived magmas and magmatic fluids. On the other hand, it should be emphasized that the proposed model is not regarded as final, but it will rather serve the base of further research. In the followings we will present the conclusions drawn on the individual formations, then a summary willl be given at the end. Details of the analytical procedures are given by DEMÉNY (1993). The data are expressed in the δ notation ($\delta = (R1/R2\ -1)\cdot 1000$, where R_1 and R_2 are the measured isotope ratios) as ‰ relative to PDB ($\delta^{13}C$) and V-SMOW ($\delta^{18}O$, δD).

* H–1112 Budapest, Budaörsi út 45.
** H–1083 Budapest, Ludovika tér 2.

THE LAMPROPHYRE-CARBONATITE SERIES

Among the lamprophyre-carbonatite occurences of the Transdanubian Mid-Mountains, the exposures of Budaliget and Pákozd, and cores of the Budakeszi-1, Budaörs-1, Alcsútdoboz-2 and Sukoró-1 boreholes were investigated, which lamprophyre magmatism was controlled by far-field extension in the hinterland of the Alpine deformation front (KÁZMÉR and SZABÓ 1989a,b). Whole rocks and phlogopite separates have oxygen isotope compositions extending from 6.0 to 9.5 ‰ that *i.* supports their mantle origin, and *ii.* points to the importance of low temperature alteration. C and O isotope data obtained on carbonates of the magmatic rocks and the surrounding formations show large scatters (*Fig. 1*) that suggest influences of different processes. Magmatic carbonate has been found only in those lamprophyre and carbonatite rocks which intruded granites, while the isotopic compositions in other dykes indicate rather low temperature carbonizations and assimilation of sedimentary material than primary magmatic origin. Formations of calcite veins within and around the dyke rocks can be related to two processes as inferred from $\delta^{13}C$ and $\delta^{18}O$ data of carbonates and δD values of fluid inclusion waters (*Fig. 2*): circulation of magmatic-meteoric water mixture and movements of another solution that resulted in precipitation of ^{13}C- depleted and ^{18}O- enriched carbonate veins. This latter fluid can be originated either from formation waters or from magmatic ones that had experienced significant degassing. Analogies in magmatic carbonate complexes support the latter possibility.

RED CALCITE DYKES

Three localities of red calcite dykes of the Transdanubian Mid-Mountains have been investigated: Sümeg, Tatabánya and Piliscsaba. Field evidence at Sümeg (HAAS *et al.* 1985) proves Aptian to lower Campanian age of dyke formation. Fluid inclusion studies of Gatter (1984) show 135–155°C crystallization temperature. However, his

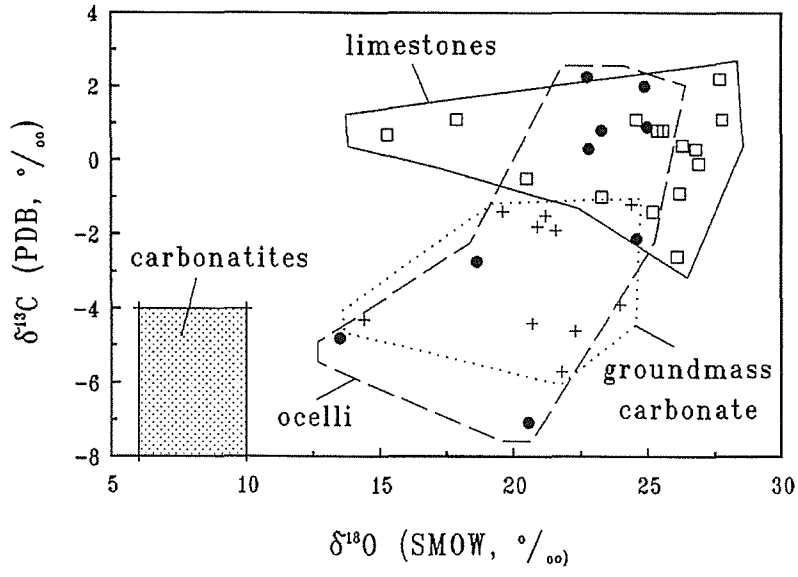

Fig. 1.
C and O isotopic compositions of carbonates formed within and around the Mesozoic lamprophyre dykes of the Transdanubian Mid-Mountains.

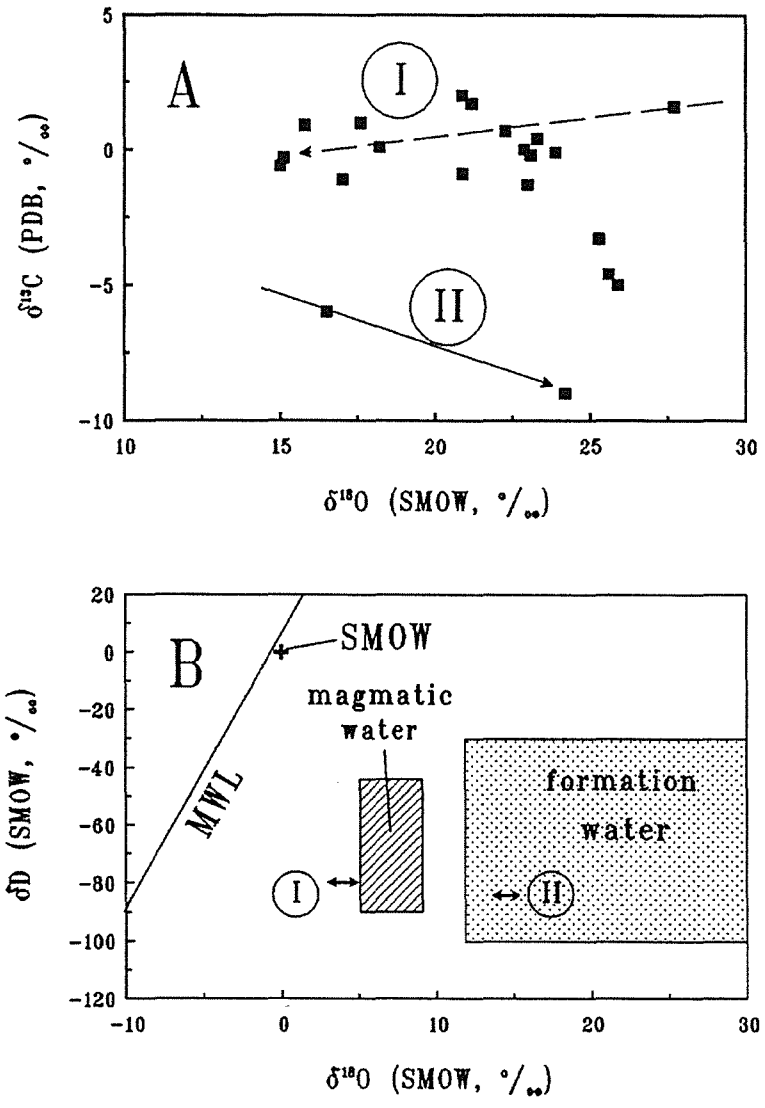

Fig. 2.

a. C and O isotopic compositons of carbonate veins related to lamprophyre dykes of the Transdanubian Mid-Mountains. Arrows indicate isotope shifts caused by circulations of magmatic-meteoric water mixture (**I**) and influence of organic-derived CO_2 or evolved magmatic fluid (**II**).

b. H and O isotopic compositions of waters responsible for carbonate vein formations. δD values are directly determined on fluid inclusion waters, $\delta^{18}O$ values are calculated from carbonate compositions and microthermometric data of DEMÉNY *et al.* (1994) using the equation of FRIEDMAN and O'NEIL (1977).

samples within the Sümeg dyke were confined to the margin of the dyke. The dykes studied show zonation with reddish brown calcite at the margins and more pale and coarser-grained calcite in the centres. The reddish brown calcite formed at the margins of the dykes and thus related to the beginning of the fluid circulation have $\delta^{13}C$ values (-10.0 to -5.2 ‰) that fall within or close to the range of magmatic C (-8 to -4 ‰, DEINES 1989). Moving to the centres of the dykes the $\delta^{13}C$ values first decrease than increase again, whereas the O isotopic compositions do not vary significantly. The inclusion water contents of calcites and their H isotopic compositions indicate mixing of two fluids (*Fig. 3*), most likely magmatic and meteoric ones. Although the $\delta^{13}C$ data alone could be originated from circulation of organic-derived CO_2, in that case the δD

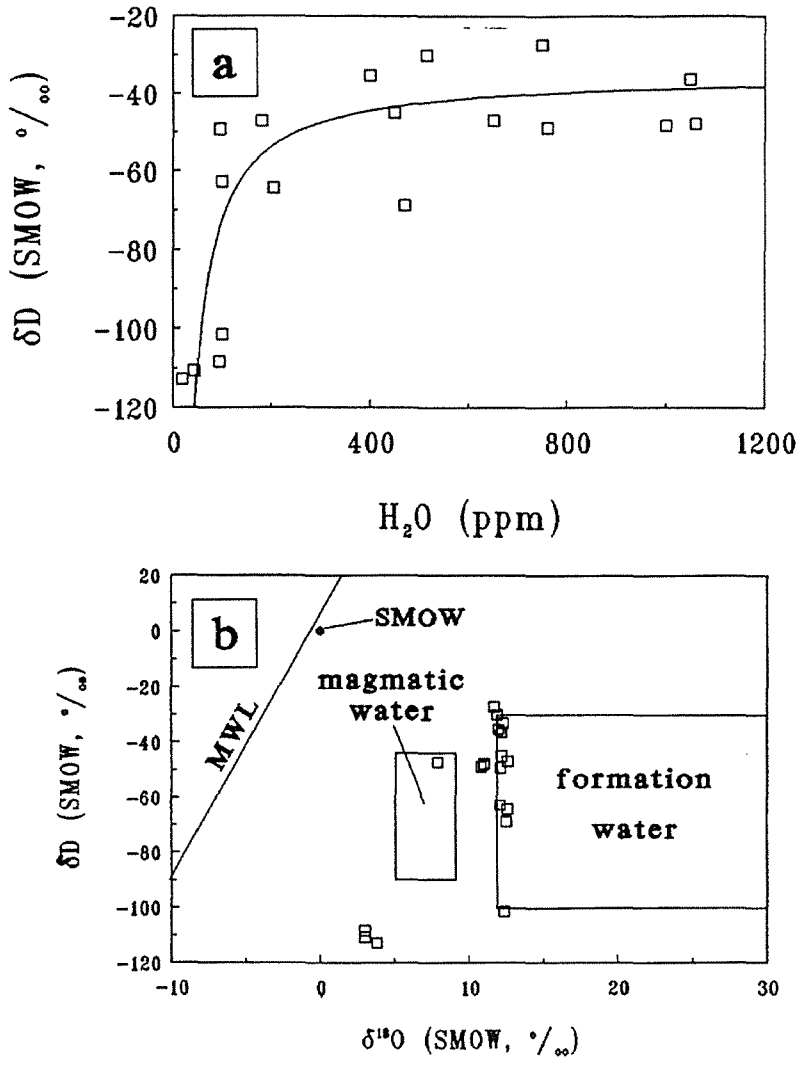

Fig. 3.
a. Inclusion water contents and their H isotopic compositions in the red calcite dykes of the Transdanubian Mid-Mountains. The curve represents a two-component mixing line (see DEMÉNY, 1993).
b. H and O isotopic compositions of waters responsible for the formation of red calcite dykes. δD values were measured on fluid inclusion waters, δ^{18}O values were calculated from carbonate compositions and microthermometric data of GATTER (1984) using the equation of FRIEDMAN and O'NEIL (1977)

data should be shifted to much more negative values (cf. "organic water" of SHEPPARD 1986). Changes in the δ^{13}C and δD data (*Fig. 4*) can be explained with superposing effects of CO_2 degassing and meteoric water infiltration. The importance of infiltrating meteoric water increased as the quantity of deep seated fluid decreased partly due to its degassing. Model calculations for such processes have lead to similar δ^{13}C–δD distributions to those measured (*Fig. 4*).

CONCLUSIONS

As it has been shown in this paper, influences of magmatic processes of Cretaceous age have been observed or presumed in the Transdanubian Mid-Mountains based on C, O and H isotopic compositions of carbonates and fluid inclusions trapped in them.

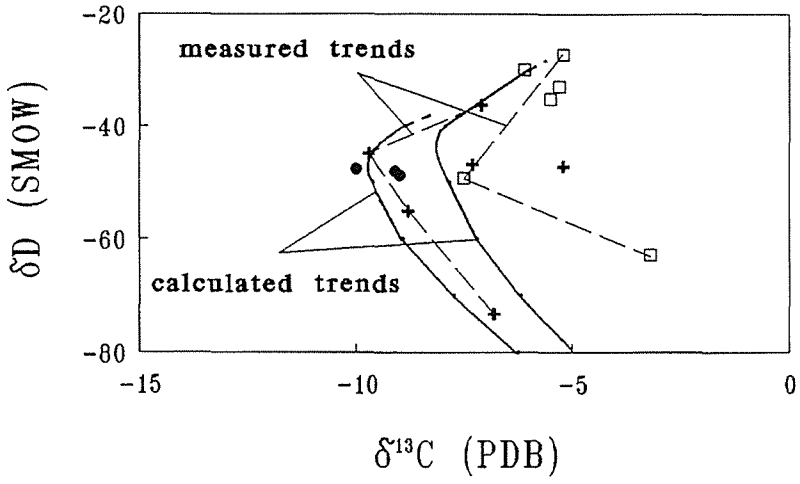

Fig. 4.
Margin-to centre trends of C and O isotopic compositions within the red calcite dykes of the Transdanubian Mid-Mountains.. Dashed curves represent results of model calculations for CO_2 degassing and meteoric water infiltration (see DEMÉNY, 1993).

Results of magmatism and magmatic fluid circulation appear in formations of lamprophyre-carbonatite bodies and red calcite dykes depending on stratigraphic level and/or time. The stable isotope results presented in this paper indicate that all these formations can be related to magmatic activity or to movements of magmatic fluids. Apart from the effect of assimmilation of sedimentary material, the carbonates associated with the lamprophyre dykes show $\delta^{13}C$ shifts from typical mantle compositions due to evolution (presumably degassing) of magmatic CO_2–H_2O fluids. The earliest carbonate precipitations within the red calcite dykes show C and H isotopic compositions that fall within or close to magmatic ranges, whereas subsequent precipitations record signs of fluid evolutions by CO_2-degassing and admixing of meteoric water. These data suggest that magmatic influences played an important role in the evolution of the Transdanubian Central Range during the Cretaceous, but of course these stable isotope data are not considered as enough to prove the direct genetic link between these processes. Further stable isotope determinations together with studies on the chronological successions and spatial positions are needed to answer this question.

ACKNOWLEDGEMENTS

The authors are grateful to JÁNOS HAAS for his help during early field trips and to ISTVÁN DUNKL for fruitful discussions. This work was financed by the Hungarian Scientific Research Fund (**OTKA** 1154).

REFERENCES

DEINES, P. (1989):Stable isotope variations in carbonatites. In: KEITH BELL (ed.): Carbonatites: Genesis and evolution. Unwin Hyman. London Boston Sydney Wellington. 301–359.

DEMÉNY, A. (1992): Hazai lamprofírok karbonátjának eredete stabilizotópvizsgálatok alapján. Földtani Közlöny. **122**, 2–4, 209–232.

DEMÉNY, A. (1993):Magmatizmushoz kapcsolódó karbonátképződés és átalakulás stabilizotópos vizsgálata. Kandidátusi értekezés.

DEMÉNY, A., FÓRIZS, I., MOLNÁR, F. (1994): Stable isotope and chemical compositions of carbonate ocelli and veins in Mesozoic lamprophyres of Hungary. European Journal of Mineralogy, **6**, 679–690.

EMBEY-ISZTIN A., Dobosi G., NOSKE-FAZEKAS G., ÁRVA-SÓS E. (1989): Petrology of a new basalt occurrence in Hungary. Mineraloy and Petrology. **40**, 183–196.

FRIEDMAN, I., O'NEIL, J. R. (1977): Compilations of stable isotope fractionation factors of geochemical interest. In. M. FLEISCHER (editor), Data of Geochemistry 6th Edition, U. S. Geol. Surv. Prof. Paper **440**,–KK.

GATTER, I. (1984): A karbonátos kőzetek érkitöltéseinek és a barlangok hévizes kiválásainak folyadékzárvány-vizsgálata. Karszt és Barlang. 1984, I, 9–18.

HAAS, J., JOCHÁNÉ EDELÉNY, E., GIDAI, L., KAISER, M., KRETZOI, M., ORAVETZ, J. (1984): Sümeg és környékének földtani felépítése. Geologica Hungarica. Ser. Geologica. **20.**

HORVÁTH I., TICHY-DARIDA M., ÓDOR L. (1983): Magnesitiferous dolomitic carbonatite (beforsite) dyke rock from the Velence Mountains. MÁFI Évi Jelentés 1981-ről. 369–389.

KÁZMÉR, M., and SZABÓ, Cs. (1989a):Late Cretaceous lapmprophyre dykes in the hinterland of the Alpine deformation front. Terra Abstract. **1**, p. 177.

KÁZMÉR, M., and SZABÓ, Cs. (1989b): Apulian plate margin geometry: Constraints inferred from Jurassic-Cretaceous neptunian and plutonic dykes. 28th. International Congress, Abstracts Vol. **2**, p. 167. Washington D. C.

KUBOVICS, I. (1985): Mesozoic magmatism of the Transdanubian Mid-Mountains. Acte Geologica Hungarica. **28**, 141–164.

KUBOVICS I., SZABÓ Cs., GÁL-SÓLYMOS K. (1989): A new occurrence of lamprophyre in the Buda Mountains, Hungary. Acta Geologica Hungarica. **32**,/1–2, 149–168.

SHEPPARD, S. M. F. (1986): Characterization and isotopic variations in natural waters. In: VALLEY, J. W., TAYLOR, H. P., Jr., O'NEIL, J. R. (eds): Stable isotopes in high temperature geological processes. Reviews in Mineralogy. **16**, 165–184.

Manuscript received 18 April, 1994.