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—

LIÈGE

EUROPEAN COLLOQUIUM OF GEOCHRONOLOGY

Brussels, 6-10 September 1971

CENTRE BELGE DE GÉOCHRONOLOGIE
BELGISCH CENTRUM VOOR GEOCHRONOLOGIE

Annales de la Société Géologique de Belgique, T. 94, 1971, p. 95-137 1971

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« Present status of the decay constants in use in geochronology ».

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« Radioactivity α and percentage of uranium and thorium of six lunar samples — Age of a sample of a lunar soil (Apollo XI).

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« Age relations in the Bergell region ».

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« Preliminary results of Rb-Sr and K-Ar age determination of granites in the Fichtelgebirge ».

H. Maluski

« Rb-Sr geochronology of the Massif des Maures (France) ».

G. Noiret

« Rb^{87}-Sr^{87} geochronology of the basement complex of the Bassin de Paris ».

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« Rb-Sr age determinations on minerals and total rocks of the Moelan and Lanvaux granites (South Brittany) ».

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« Geochronologie du Socle du Massif Central »

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« Geochronological events in the Precambrian history of the Eastern part of the Baltic Shield by Pb-U-Th method ».

S. B. LOBACH-ZHUCHENKO, E. K. GERLING and T. V. KOLZOVA

« K-Ar geochronology of the Baltic Shield ».

K. O. KRATZ and S. B. LOBACH-ZHUCHENKO

« Geochronological boundaries and geological evolution of the Baltic Shield ».

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« Geochronological map of crystalline basement in the South-West part of East-European platform and its folded frame ».

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« Rb-Sr and U-Pb zircon age work on granites of the Ketilidian mobile belt (early Proterozoic), South-Greenland ».

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« Anomalous $^{18}O/^{16}O$ ratios in rhyolitic rocks.

S. FOURCADE and M. JAVOY

« Isotopic temperatures in low pressure granulite facies ».

G. D. Afanass'yev (*)

Geologo-petrological and geochronological investigations in Central Caucasus as a basis for understanding the complicated relationships between the sedimentary, metamorphic and magmatic rocks

The Eastern part of Central Caucasus, limited by the rivers of Ardon and Terek, is an exceedingly geologically complicated region of the Great Caucasus. Large areas of pre-Paleozoic substratum and Upper Paleozoic granites within the Main Range, which are constituting the crystalline core of the Great Caucasus East of Ardon river, have been tectonically subsided. Within the subsided Ardon-Terek block the Lower Paleozoic crystalline schists and argillites metamorphozed up to phyllites are extended (spot like) in alternation with the bands of conglomerates and sandstones.

The age of this meta-sedimentary series has been discussed for about 100 years. Most geologists, following H. W. Abich and I. G. Kuznetsov, reported it to Liassian. Other ones believe these rocks to be Paleozoic (Devonian-Carboniferous). Sufficiently reliable finds of fauna being lacking, this point cannot be answered uniquely.

This series of uncertain age is intruded by microcline granites (Zeija, Fiagdon, Daryal massifs) and gabbroid dikes which do concentrate in several distinct knots (clusters) constituting up to 60 % of the geological sequence. Granitoids and crystalline schists of Daryal and Kassaren massifs contain pseudo-cross-cutting gabbroid bodies. During the Jurassic stage of Great Caucasian evolution, the Ardon-Terek block has been subsided down to the level of geoisotherms which induced the loss of radiogenic argon by the feldspars and led to a general rejuvenation of rocks (whole rock samples) up to Middle-Upper Jurassic ages.

At the Northern periphery of the block a granitoid Middle to Upper Jurassic formation was emplaced, running parallel to a tectonic fault. At the Southern block periphery, in the neighbourhood of the Main Range cross-passes, granited stocks 1.5-2 m.y. old are found and the well known extinct volcano of Kazbek, located along a latitudinal fault.

Due to geologo-petrological and radiological investigations a more unambigous notion was attained about the time of origination of various rocks and the diversity in their relationships.

(*) Academy of Sciences USSR, Storo-Monetny/Igem, Moscow B-17.

C. J. Allegre, J. L. Birck, M. Loubert, A. Provost (*)

Rb-Sr Age and Rb-Sr-Ba-Rare Earth content of luna 16 soils

The Luna 16 soil is the least radiogenic soil yet recovered from the Moon.

The $^{87}Rb/^{86}Sr$ ratio is about 0,024 and the $^{87}Sr/^{86}Sr$ about 0.70040. The point that represents the Luna 16 soil is the least radiogenic one, but still lies on the « soils line » defined by Papanastasiou and Wasserburg which corresponds to an age of about 4.6 B.Y.

The K, Rb and rare earth contents are the lowest yet found in lunar soil and also the Eu anomalies are the lowest. However the Sr content is the highest found

so far. Some relation is found in the soil, between the Eu anomaly and the R.E. content, and also between the K and Rb contents.

The authors think that this result proves that the exotic components are not only KREP, but also components poor in K, Rb and R.E. and older than 4.6 B.Y.

(*) Groupe de Recherches Géochimiques Louis Barrabé, Institut de Physique du Globe, Université de Paris VI, 9, quai St-Bernard, Paris V.

C. J. Allegre (*), R. Caby (**)

Ahaggar precambrian geochronology

Using Rb-Sr, U-Th-Pb and K-A methods we can make an absolute Precambrian Geochronology which is the following:

Early Precambrian at 3300 MA. Intrusion of granites and aplites at 2300 MA. Granitisation at 2050 MA. Stromatolithe series deposition beginnnig at 800 MA. Pan African orogeny begins at 620 MA and intrusion of granites occurs at 550 MA. Metamorphism at 420 MA, (and possibly at Hercynian time).

Comparison with other countries in Africa is given.

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(**)Centre de Recherche des Zones Arides, C. N. R. S., Université de Montpellier.

M. M. Arakelyants (*), G. D. Afanass'yev (**) and I. Nachev (***)

New K-Ar data for the Mesozoic part of the geochronological time scale

As a supplement to data previously published in the Proceedings of the XXIII Session of the International Geological Congress and in a special volume of « Eclogae Geologicae Helvetiae » (Papers presented at the Colloquium on the Geochronology of the Phanerozoic Belts, Switzerland, 1969) latest K-Ar dates are presented. They were determined recently on Ypresian, Campanian, Barremian and Goterivian glauconites from Bulgaria and on Lower to Middle Jurassic effusives from the North Caucasus (U.S.S.R). The obtained numerical values do corroborate the validity of the Soviet Geologic Time-Scale of 1964 (by Afanass'yev et al.) and again yield more details for its revision.

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(**) Academy of Sciences, U.S.S.R. Storomonetny, Igem, Moscow B-17.
(***) Bulgaria.

J. Arden and N. H. Gale (*)

A new electrochemical method for the separation of trace amounts of lead from sillicates and its application to provide new uranium-lead data on stony meteorites

A new electrochemical method has been developed for the separation of trace amounts of lead from silicates. The technique involves successive cathodic and anodic

electro-deposition onto platinum electrodes; methods have been derived to overcome all major interferences. Yields consistently greater than 80 % have been demonstrated for the separation of amounts of lead in the range 0.1 μg to 10 μg, with a blank level per separation (for 1 g. of stony meteorite) of 6 ± 2 nanograms Pb. In addition a novel ion exchange procedure has been developed for the separation of uranium and thorium; the blank per separation for uranium is 0.1 nanograms.

The techniques have been applied to provide new U/Pb data on stony meteorites. For the first time sampling difficulties have been avoided by determining uranium and lead concentrations and lead isotopic abundances on physically the same sample of each meteorite studied. The meteorites studied were Appley Bridge (LL6), Barwell (L6), Bruderheim (L6) and Peace River (L6); all of these meteorites are falls, and the first three were recovered the next day after fall, so minimising the possibility of terrestrial contamination. In each case there is now too little uranium to support the lead isotopic concentrations and the lead/lead age; furthermore each of these meteorites lies to differing degrees off the presently accepted meteorite lead/lead isochron. Further work will be required in order to explain these facts.

A lead composition more primitive than that found in the troilite phase of iron meteorites has been found in a troilite segregation in the Appley Bridge amphoterite. Further U/Pb work is planned on separated phases of stony meteorites in an attempt to understand this result.

(*) Department of Geology and Mineralogy, The University of Oxford, Park Roads, Oxford.

R. D. Beckinsale (*) and N. H. Gale (**)

Present status of the β decay constants in use in Geochronology

Naturally occurring long-lived nuclides decaying by β-decay and related processes are ^{40}K, ^{50}V, ^{87}Rb, ^{115}In, ^{123}Te, ^{138}La, ^{176}Lu and ^{187}Re. Established methods of radiometric age determination are based on the decays $^{40}K \rightarrow {}^{40}Ar$, $^{87}Rb \rightarrow {}^{87}Sr$, $^{176}Lu \rightarrow {}^{176}Hf$ and $^{187}Re \rightarrow {}^{187}Os$. Of the rest of these active nuclides the β-branch $^{138}La \rightarrow {}^{138}Ce$ is probably potentially more promising than the electron capture branche $^{138}La \rightarrow {}^{138}Ba$ because of the relative natural abundances of the daughter nuclides. It appears unlikely that ^{50}V or ^{115}In will ever provide methods of age determination since their decay constants are of the order of 10^{-16} yr^{-1} and 10^{-15} yr^{-1} respectively.

It is only possible to draw geological conclusions from the degree of concordance of ages determined using different decay schemes (for example, cooling rates of plutonic rocks) if the decay constants used to calculate these ages are sufficiently accurate and independent. Thus values for decay constants calculated from absolute measurements of the specific activities (= disintegrations per second per gramme) should be adopted in preference to values derived by geochronological comparison of results from different decay schemes, which depend on the *assumption* of a particular pattern of concordance. It may be necessary to make an exception to this general rule in the case of ^{187}Re since the β-energy is so low that direct physical measurements of the specific activity are exceedingly difficult.

The decay constant of ^{87}Rb has proved a particularly acute problem in geochronology since three significantly different values are in use in the literature

— $(1.47 \pm 0.03) \times 10^{-11}$. yr^{-1}, 1.43×10^{-11} . yr^{-1}, and $(1.39 \pm 0.06) \times 10^{-11}$. yr^{-1}. The 1.47×10^{-11} . yr^{-1} value is based on liquid scintillation counting (Flynn and Glendenin, 1959), the 1.39×10^{-11} . yr^{-1} value is based on geochronological comparison (Aldrich et al., 1956), and the 1.43×10^{-11} . yr^{-1} value is simply the average of the former two values. Two recent physical determinations of this decay constant have yielded values of $(1.45 \pm 0.03) \times 10^{-11}$. yr^{-1} (Kovach, 1965) : liquid scintillation) and $(1.47 \pm 0.01) \times 10^{-11}$. yr^{-1} (McMullen, Fritze and Tomlinson, 1966 : direct mass spectrometry). Further liquid scintillation counting experiments by the authors are in progress to help establish the decay constant of ^{87}Rb more accurately. There is little doubt, however, that the best physical determinations yield values between 1.44×10^{-11} . yr^{-1} and 1.47×10^{-11} . yr^{-1}.

The most reliable values for the decay constants of ^{40}K are those recommended by Beckinsale and Gale (1969) although some authors still adopt the values recommended by Smith (1963). The concordance of Rb-Sr and K-Ar ages frequently obtained using the 1.47×10^{-11} . yr^{-1} decay constant for ^{87}Rb and the decay constants for ^{40}K recommended by Smith (1963) may indicate that the calculated ages in both cases are about 1 — 2 precent too young. In the interests of uniformity it is probably advisable that one value for the decay constant of ^{87}Rb should be adopted until such time as a more accurate value is available. We suggest that the $(1.47 \pm 0.03) \times 10^{-11}$. yr^{-1} value is the most reliable of those in use and it is in any case within the limits of error of the geochronologically determined value — $(1.39 \pm 0.06) \times 10^{-11}$. yr^{-1}.

From a close scrutiny of the accounts of counting experiments on the various nuclides (references up to 1966 are tabulated in Lederer, Hollander and Perlman, 1967) it is possible to decide which determinations of the decay constants are likely to be the most accurate. On this basis we recommend the values for the various-decay constants set out below. We have adopted the decay constants of ^{40}K recommended by Beckinsale and Gale (1969), the $(1.47 \pm 0.03) \times 10^{-11}$. yr^{-1} value for ^{87}Rb for the reasons discussed above, and the value of $(1.61 \pm 0.19) \times 10^{-11}$. yr^{-1} for ^{187}Re obtained by Hirt et al. (1963).

Nuclide	*Isotopic Abundance* (%)	*Decay Constant(s)*
^{40}K	0.0118	$\lambda\beta^-$ $(4.905 \pm 0.009) \times 10^{-10}$. yr^{-1}
		λe^- $(0.566 \pm 0.0035) \times 10^{-10}$. yr^{-1}
		$\lambda' e$ $(8.67 \pm 1.74) \times 10^{-13}$. yr^{-1}
^{87}Rb	27.85	$\lambda\beta^-$ $(1.47 \pm 0.03) \times 10^{-11}$. yr^{-1}
^{138}La	0.089	total λ $(6.2 \pm 0.8) \times 10^{-12}$. yr^{-1} (approx 30 % β^-, 70 % E. C.)
^{176}Lu	2.60	$\lambda\beta^-$ $(1.94 \pm 0.04) \times 10^{-11}$. yr^{-1}
^{187}Re	62.93	total λ $(1.61 \pm 0.19) \times 10^{-11}$. yr^{-1}

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C. BESANG, W. HARRE, H. KREUZER, H. LENZ, P. MÜLLER, I. WENDT (*)

PRELIMINARY RESULTS OF Rb/Sr AND K/Ar AGE DETERMINATION OF GRANITES IN THE FICHTELGEBIRGE

According to Stettner four phases of granite-intrusions can be distinguished. Suites of samples from each granite have been dated by the whole rock-Rb/Sr-isochron method. From two granites also muscovites and biotites were dated. The following results were obtained.

	Granite		m. y.	$(^{87}Sr/^{86}Sr)_0$ initial
G 1	Weißenstadt-Marktleuthen Porphyrygranite	whole rock	312 ± 20	0.7082 ± 0.0011
G 2	Randgranite	whole rock	290 ± 8	0.7148 ± 0.0029
	»	minerals	283 ± 3	0.728 ± 0.019
	»	whole rock + minerals	284.5 ± 2.1	0.7170 ± 0.0014
G 3	Kerngranite	whole rock	287.8 ± 4.0	0.7169 ± 0.0015
G 4	Zinngranite	whole rock	285.5 ± 6.1	0.694 ± 0.019
		minerals	291 ± 10	—
		whole rock + minerals	285.1 ± 2.2	0.695 ± 0.011

($\lambda^{87}Rb = 1.47 \times 10^{-11} y^{-1}$)

The Zinngranite has an extraordinarily low concentration of common Strontium (whole rock down to 2 μg/g) which causes extremely high $^{87}Sr/^{86}Sr$ ratios (whole rock between 1.3 and 5.9, micas between 34 and 94).

K/Ar age determinations of muscovites and biotites of « Randgranite » and « Zinngranite » samples yield values between 283 m. y. and 299 m. y. and they may be regarded to be of equal age within the limits of their individual errors of $\pm$ 4 m. y. The average K/Ar ages of 288.6 ± 0.9 m. y. (s = 3.8 m. y.) of the biotites and 291.2 ± 1.6 m. y. (s = 0.5 m. y.) of the muscovites are slightly but not significantly

higher than the Rb/Sr-mineral-isochron results of 284.5 $\pm$ 2.1 m. y. and 285.1 $\pm$ 2.2 m. y. respectively.

The ages of the four granites investigated cannot be resolved significantly. But some mineral dates of the Weissenstadt-Marktleuthen-granite confirm a higher age of this granite compared to G 2, G 3 and G 4.

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Oxford Isotope Geology Laboratory.
(L. P. Black, N. H. Gale, S. Moorbath, R. J. Pankhurst (*)
and V. R. McGregor) (**)

Isotopic dating of very early precambrian amphibolite facies gneisses from the Godthaab district, West Greenland

Amphibolite-facies feldspathic gneisses (the Amitsoq gneisses) from the Godthaab area of West Greenland give hitherto unique age and isotope data, including i) a Rb-Sr whole rock isochron age of 3980 $\pm$ 170 m. y. ($t\ ½ = 5.0 \times 10^{10}$ y) with an initial $^{87}Sr/^{86}Sr$ ratio of 0.6992 $\pm$ 0.0010, ii) a Pb-Pb whole rock isochron age of 3620 $\pm$ 100 m. y., and iii) extremely unradiogenic whole-rock leads, with $^{206}Pb/^{204}Pb$ and $^{207}Pb/^{204}Pb$ values extending down to 11.51 and 13.14 respectively. Taken together, these data provide the first direct evidence for the existence of a granitic crust so early in the Earth's history. The isotopic evidence also demonstrates that these rocks could not have had a lengthy (i. e. more than a few tens of millions of years) history prior to the Rb-Sr isochron age. Possible interpretations of the isochron ages are discussed in detail.

Several other petrologically distinctive rocks from the same area are shown to have been affected by thermal events somewhere in the range 2000-2800 m. y. ago.

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N. A. I. M. Boelrijk (*)

Comparison of precision in single and double isotope dilution analysis

Gain in accuracy, — due to correction for mass discrimination by double isotope dilution analysis, — is obtained at the expense of precision. Loss of precision may be considerable when an unfavourable mixing ratio between spike and unknown has been used. A method is proposed to decide whether the result evaluated by single or by double isotope dilution calculation should be preferred. The decision takes into account the quality of the mass spectrometric analysis, and is not based on assumptions concerning the precision of the isotopic ratio determination.

The spectrum is scanned repeatedly, and divided into at least 10 independent groups of equal size. For each group the content p is calculated by double and single isotope dilution calculation (respectively p_d and p_s), the latter by using a long-time average $\in = \in_0$ in the mass discrimination correction factor $1 \pm n\in$, where n is the mass difference expressed in mass units. The averages $\bar{p}_s$ and $\bar{p}_d$ and variances

var ($\bar{p}_s$) and var ($\bar{p}_d$) for the analysis are obtained in the usual way. The average $\in_0$ and the « between-runs » variance of $\in$, var ($\in$), are obtained from repeated measurements of a constant isotopic ratio over a long period.

Single isotope dilution calculation is preferred when

$$\text{var}\,(\bar{p}_s) + \left(\frac{\delta p_s}{\delta \in}\right)^2 \text{var}\,(\in) < \text{var}\,(\bar{p}_d).$$

The value of the partial derivative $\delta p_s/\delta \in$ is evaluated for $\in = \in_0$ and the average value(s) of the measured isotopic ratio(s) in the mixture on which the determination is based. The method applies e. g. to the evaluation of « initial » strontium, « radiogenic » strontium, and also to the evaluation of the $^{87}Sr/^{86}Sr$ ratio in the original sample, which ratio is often needed for isochron calculations.

A statistical expression for the error magnification factor in double isotope dilution has been derived. It is shown that the very high error magnification which occurs at some mixing ratios, can be brought down to a normal level, without loss of precision at other mixing ratios, by a simple change in the composition of the spike.

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S. Borsi, A. Del Moro, G. Ferrara (*)

Radiometric ages of Ivigna, Bressanone and M. Croce massifs (Eastern Alps)

Rb/Sr measurements have been carried out on total rocks and separate minerals on the three massifs.

The data obtained suggests a common genetic origin for Ivigna and Bressanone massifs together with an Hercynian age (270 — 280 MY); they exibit a very close Sr^{87}/Sr^{86} initial isotopic composition (0.705 — 0.706).

A pre-Hercynian age (360 — 385 MY) has been obtained from the total rocks isochron of the two separate bodies.

For the M. Croce massif the separate minerals still give an Hercynian age (260—270 MY) and the same value has been obtained for the total rocks isochron (270 MY) that gives a Sr^{87}/Sr^{86} initial isotopic composition of 0.712.

These data will be discussed in relation with the other « periadriatic massifs ».

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S. Borsi, G. Ferrara (*)

Detailed K-Ar chronology of the rocks of the intrusive complex of the Elba Island

The results of a systematic K-Ar dating of rocks belonging to the acid intrusive complex of Elba island in the Northern Tyrrenian sea, are reported.

The complex consists of two principal intrusive granodioritic bodies emplaced during a slightly different time (7 and 6 MY ago); associated to them, there are numerous masses, dykes and veins of rocks more or less differentiated and ore deposits. The detailed age determination study carried out on these rocks offers new

informations for the reconstruction of the magmatic processes and of the geologic evolution of this intrusive complex.

Furthermore the presence of pebbles of porphyd and so-called « eurite » in conglomerates representing the Miocene-Pliocene boundary enables us to define in more detail the value of this limit.

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S. B. Brandt, G. S. Plyusnin, V. N. Smirnov, N. V. Volkova (*)

The reconstruction of the primary K-Ar age of a rock departing from discordant ages of its mineral fractions

Continual and episodic models of argon migration are developed, in connection to two problems.

(a) Provided in a two-phase system the equilibrium in one of the phases may be believed as undisturbed, then the migration properties of the argon in the other phase may be estimated without laboratory treatment of the samples.

(b) If the Ar^{40}/K for two phases of a system and the diffusion parameter for one of them are known, the primary equilibrium conditions as well as the diffusion parameter for the other phase can be determined.

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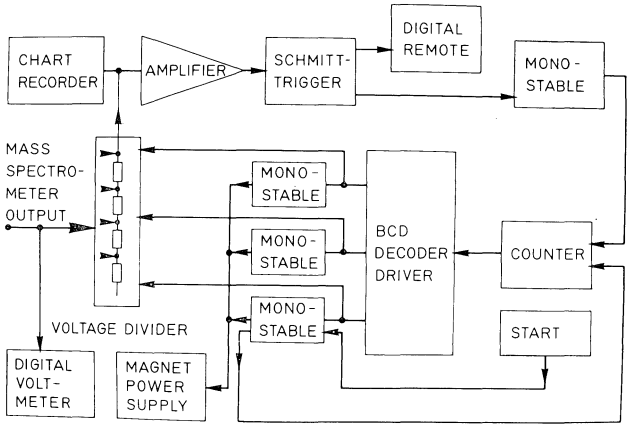
R. Brunner (*)

Psorn — X

The Psorn-X contains different programs for Pb, Sr, O, Rb, and normal collector measurements for mass spectrometers with analogue and/or digital output. X indicates, these programs are expandable for any other isotopic ratios by means of an electronic logic programming card.

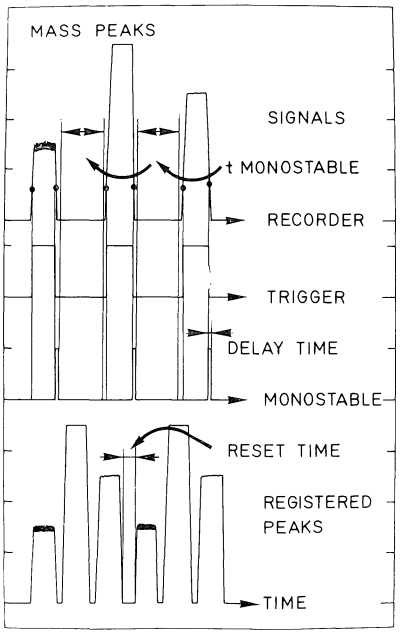
Working in parallel with the chart recorder is a high impedance type operational amplifier connected to a very stable Schmitt-trigger. (Fig. 1). The triggered signal



is delayed in a monostable multivibrator circuit. The delay time depends on the type of mass spectrometer. The multivibrator output signal is connected to the BCD counter. At the BCD output, the coded information is stored ,as mass number, voltage range, scan speed and time.

For different scan ranges there are different monostable circuits.

It is much easier to explain the system by means of Fig. 2.



The first peak appears. On a defined voltage level the Schmitt-trigger switches from off to on. At the negative peak edge, the trigger switches off again. This off-switching pulse causes a delay signal from the following one shot. The one shot goes to the logic and it says for example :

Fast scan pulse from 84 to 86 !

Voltage range from 100 mV to 1 V !

It is possible to select the voltage ranges before or during the measurements.

For digital measurements which includes (Fig. 1) digital remote control, the trigger signal is taken from the positive peak edge.

Using special digital logic a command is sent to the digital voltmeter to indicate the range, position and number of measurements.

By means of a special circuit it is possible to see at the chart recorder the exact position of the digital measurements.

The advantage of the logic system is not only less manual work. Even for analogue measurements the accuracy is increased by about 50 %.

The performance of these circuits :

The work without any external clock pulse or steering. — It is controlled by the peaks themselves. If a peak is cut off by an error or instability in the magnet power supply, the automatic makes the correction at the same peak.

The start signal for the following peak is only given when the first one is measured.

It is possible to use the Psorn for peak switching. But with an old machine we preferred a good scan unit rather than a poor switching system.

But only the digital system gives the full performance.

Most of the circuits are monolithic integrated TTL's.

The 8 plug-in cards containing the whole system are easy to operate, even for geochronologists.

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N. Clauer and M. Bonhomme (*)

Preliminaty Rb/Sr dating in the upper Precambrian Near Atar (Mauritania)

The Upper Precambrian Stromatolite formation of Atar (Western Part of the Taoudeni basin) rests unconformably on the Reguibat craton, 2000-2600 M. Y. old. The present data of 863 $\pm$ 78 M. Y. was determined in an argillaceous horizon of this sequence by the Rb/Sr isochron method (1,47 10^{-11} y^{-1}).

This isochron includes all the four fine fractions and one of the total rocks. The three other total rocks contain much more detrital material and their points lie above the fine fraction isochron. The initial ratio : 0,709 $\pm$ 0,010, the clay mineralogy and the chemical analyses of the fine fractions lead us to think that this age may represent an early sedimentary diagenesis and may be considered as stratigraphically meaningful.

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M. Condomines, M. Bernat, C. J. Allegre (*)

Io/U studies in volcanic rocks : consequences of magmatic processes

Total analysis of volcanic rocks from Costa Rica and Hawaii by Io/U isotope method prove that in these two areas the magmas do not pass directly from the mantle to the surface but are stored for some time in a magmatic reservoir. During the transfer from the Mantle to the magmatic reservoir and during the storage in this reservoir some important chemical fractionation affects the U/Th ratio.

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R. Coppens and Ch. Kosztolanyi (*)

α radioactivity and uranium and thorium contents of six lunar samples age of a sample of a lunar soil (Apollo XI)

I. *U and Th contents of lunar samples*

The α radioactivity and the uranium and thorium contents of four rocks samples and two moon soil samples have been determined by α autoradiography using Ilford K_2, 50 μ nuclear plates.

The observations of the developed emulsions have been done with a high-power microscope in order to adjust only on the emulsion surface.

To eliminate the parasite traces coming from the radioactivity of the glass-support and of the gelatine, spotless plates have been developed and the traces examined in the same conditions. So, we have been able to calculate a background which has been taken in account afterwards.

The ratio $\frac{Th}{U}$ has been estimated by measuring the number ν_1 of α rays having in air a length superior to 7 cm (Th C') and the number ν_2 of rays having in air a length comprised between 5,8 and 7 cm (Th C′ partially absorbed + Ra C′ or AcA). This ratio $\frac{Th}{U}$ is,

$$\frac{Th}{U} = \frac{3{,}3}{\frac{\nu_2}{\nu_1} - 0{,}80} \simeq 5$$

The absorption coefficient K of α rays by rocks and soils has been calculated from average chemical composition of major elements deduced from Kaplan's measures.

Si = 19 %		Mg = 7 %		
Al = 7 %		Ca = 7 %		$O_2 = 42$ %
Fe = 16 %		Ti = 2 %		
We found		K = 15,3		

Taking in account all these data, we found,

n_0S		U µg/g	Th = 5 U µg/g
rocks	12 063	0,39	1,94
	12 065	0,26	1,30
	12 018	0,66	3,29
	12 004	0,33	1,64
soils	Apollo XI	0,63	3,15
	Apollo XII	1,12	5,60

On the whole, the distribution of α traces seems to be regular. However, we may notice, now and then, some more numerous α which would let suppose the existence of low concentrations — or inclusions — in certain points.

II. *Age of the soil* (Apollo XI)

Some granules measuring a fraction of mm^3 and the mean weight of which can be estimated at 1 mg, have been extracted from the soil sample 10 084,142.

The age of some particles could be calculated by measuring the isotopic ratio $^{207}Pb/^{206}Pb$ applying an activation method perfected at the Center for Radiogeological Research of Nancy.

We found the following results :

	$^{207}Pb/^{206}Pb$		Age in M. Y.
	0,480 66		4 240
	0,482 55		4 250
	0,454 32		4 160
	0,438 21		4 110
	0,460 00		4 180
	0,485 18		4 260
Mean	0,461 73	Mean age :	4 180 $\pm$ 90 M. Y.

The mass spectra of lead did not reveal any ^{204}Pb

The found values as well concerning the content of uranium or thorium, as concerning the age correspond to those obtained by G. Kaplan for the same samples by entirely different methods.

	C. R. R.	G. Kaplan
U (μg/g)	0,565	0,55
Th (μg/g)	2,82	3,26
Age (M. Y.)	4 180	4 250

The interest of our method arises from two main facts :

1. — The radioactivity measurements are not destructive;
2. — The age measurements need only infinitesimal fractions (some mg) of materials.

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J. Delhal (*), D. Ledent (**), P. Pasteels (***) and J. Venier (**)

Isotopic evolution of Rb/Sr systems in a peralkaline granite

U/Pb and Rb/Sr measurements have been performed on the peralkaline granite from Noqui (Angola and Lower Congo) near Matadi. This aegyrine-riebeckite and lepidomelane granite is situated in the old gneissic basement of the West-Congolian orogeny, the ultimate tectonic phase of which is somewhat older than 620 m. y. It is considered to have been formed by an atectonic metasomatic process. In some portions however it has the appearance of a completely magmatic granite. It is affected by a slight cataclasis.

U/Pb measurements on three fractions of a zircon rich in common lead do not allow a precise datation for the formation of the granite but yield a minimum figure of 760 m. y. Rb/Sr measurements yield good isochron ages for two isotopic rehomogenisations of strontium : one for five total rocks at 533 $\pm$ 1 1m. y. with a Sr^{87}/Sr^{86} initial ratio of 0,8633, and another at 454 ($\pm$ 2 m. y.) represented by two parallel mineral isochrons (aegyrine — total rock — microperthite) for the most alkaline specimens. In the less alkaline samples, mineral rehomogenisation has not been completed.

The representative points of the feldspar fall, in these cases, bewteen the 533 m. y. isochron and the 454 m. y. isochron passing through the corresponding W. R. point.

The two phases of rehomogenisation occur later than the last tectonic phase responsible for the cataclasis; they do not correspond to any petrographically perceptible event. They probably represent discrete steps of a slow uplift of the whole region during post-tectonic phases of the West-Congolian orogeny. They indicate for the different granite samples a closing of the Rb/Sr system which occurs later in the samples having the highest Rb/Sr ratio.

The 450 m. y. figure coincides with the lowest values found in the entire area affected by the West-Congolian orogeny, and which were measured on biotite.

This work is part of the programme of the Belgian Center for Geochronology.

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M. H. Dodson and D. R. Dickinson (*)

False « isochrons » and their petrogenetic significance

Suites of potassic volcanic rocks commonly display a positive correlation between $^{87}Sr/^{86}Sr$ and Rb/Sr. Calculated « ages » from these « isochrons » are substantially greater than the age of eruption. For suites of young, silica-poor rocks from the Western Rift, Central Africa, (Bell and Powell, 1969) and Wyoming (Peterman, Doe and Prostka, 1970) the Rb-Sr « ages » are 700 and 300 m. y. respectively. For suites of highly siliceous rocks of comenditic or pantelleritic character from continental environments (Dickinson et. al., 1969; Barberi et. al., 1970; Dickinson and Gibson, 1971) the Rb-Sr « ages » are lower (3 m. y. to 40 m. y.) but are still substantially greater than the age of extrusion. New data from Easter and Ascension Islands display a comparable pattern.

None of the results can be explained satisfactorily by bulk assimilation of crustal rocks, because of the very high potassium contents which would be necessary. Partial assimilation is capable, in principle, of accounting for the results for the W. Rift and Wyoming : either partial melting of potassic mineral phases, or preferential migration of ^{87}Sr from potassium sites, could result in separation of radiogenic ^{87}Sr from normal strontium (Heier, 1964). Comigration of Rb and associated ^{87}Sr into the magma-forming fluids might be expected to occur with either mechanism : the apparent Rb-Sr age of the rocks so formed would be equal to the age of the source rocks, if no isotopic homogenisation occurred between fluid and source. A comparison of basement age with apparent Rb-Sr age suggests that the extent of isotopic homogenisation was not very great in the Western Rift, somewhat greater in theAbsaroka field, and complete in other alkalic rocks studied by Powell and Bell (1970).

A crustal origin for the high $^{87}Sr/^{86}Sr$ ratios in the high silica materials cannot be excluded where they are formed in a continental environment. For comparable materials on Easter and Ascension Islands, however, contamination in the usual sense appears unlikely. Radiogenic ^{87}Sr may be derived from earlier-formed components of these volcanic islands by one or both of the fractionation processes described above. Alternatively, a preliminary mathematical analysis of $^{87}Sr/^{86}Sr$ development in a

fractionating petrological system suggests that the observed pattern of Rb-Sr data could be quantitatively explained even if the Sr isotopes are not separated during chemical differentiation.

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S. Fourcade and M. Javoy (*)

Isotopic temperatures in low pressure granulite facies

The $^{18}O/^{16}O$ ratios of whole rocks and minerals have been measured for some samples of the old acidic shield of In Ouzzal (3.3 By), in the N. Western part of Ahaggar. This shield consists principally of paragneisses with mineral association typical of a « low pressure » catazonal metamorphism (eg : biotite-cordierite-sillimanite-almandine-hypersthene). Isotopic fractionations between coexisting minerals correspond to temperatures of 780°C to 820°C. As these rocks show almost no trace of mobilization this implies a very low water pressure.

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S. Fourcade and M. Javoy (*)

Anomalous $^{18}O/^{16}O$ ratios in rhyolitic rocks

The whole rocks $^{18}O/^{16}O$ ratios in the ignimbritic and rhyolitic series of In'Zize (age : 530 M. Y.), in the Ahaggar, are very low and very uniform ($\delta = +2.7$ to $+2.9$). This seems to be related to the situation of this massif near the tectonic edge of the Precambrian shield of In Ouzzal and directly above a large fracture zone. These low δ values are in good agreement with a model of percolation within these fractures, of large amounts of meteoric water, first altering the isotopic composition

of the In'Ouzzal paragneisses from a $\delta = + 6.5$ to a $\delta = + 0.45$, and subsequently the whole acidic magma.

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GEBAUER D. and GRÜNENFELDER M. (*)

COMPARATIVE Rb/Sr AND U/Pb STUDIES OF MIGMATIC ORTHO- AND PARAGNEISSES

In interpreting Rb/Sr and U/Pb data obtained from metamorphic rocks the problem is whether one dates the event of metamorphism or respectively that of intrusion or sedimentation.

Within a single quarry a suite from non-anatectic paragneisses over partial to completely molten gneisses has been studied in detail. The results show that both the paragneisses as well as their diatectic derivates form an isochrone. U/Pb ages of zircon suites and Rb/Sr mineral systems reveal the existence of a later thermal event.

The same systematics are also observed in migmatized orthogneisses. Their anatectic melts define internally an isochrone which coincides with that for the source material.

In both cases the results are interpreted to indicate the approximate time of anatexis.

Slightly metamorphosed pelitic and psammitic layers of Upper Cambrian age (fossiliferous Potsdamian) give, according to preliminary results, an isochrone of early Hercynian age. It is therefore suggested that sediments showing a Sr homogenisation do not necessarily date the time of deposition or diagenesis.

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I. M. GOROKHOV, E. K. GERLING (*)

Rb-Sr GEOCHRONOLOGICAL STUDY OF THE EASTERN PART OF THE BALTIC SHIELD : A PROGRESS REPORT

Strontium isotopic ratios and rubidium and strontium abundances are given for about 160 samples of Precambrian rocks and minerals.

The Rb-Sr whole rock ages of the Belomorian and Kola gneisses and of Karelides basement granites are 2500-2760 m. y. ($\lambda\, Rb^{87} = 1.39.10^{-11}\ yr^{-1}$). Metamorphism of the Early Karelian supracrustal rocks (Himola Series) and the emplacement of granites occured 2180-2330 m. y. ago. The next stage of Karelian metamorphism and granite formation is dated in the North Ladoga Region by the range of 1815-1885 m. y. — 1900-2200 m. y. ago retrogressive metamorphism of basement rocks resulted in decrease of their muscovite and potassium feldspar ages. Late Karelian metamorphism of the sedimentary Pechenga and Lake Segozero rocks occured apparently 1660-1685 m. y. ago. Biotites of older rocks have similar Rb-Sr ages.

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B. GRAUERT, R. HÄNNY and G. SOPTRAJANOVA (*)

U-Pb ISOTOPIC RELATIONSHIPS IN ZIRCONS OF UNMETAMORPHOSED AND METAMORPHIC PALEOZOIC SANDSTONES

U-Pb isotopic measurements have been reported for zircon suites of stratigraphically known Lower Paleozoic sandstones from the Saxothuringicum and of quartzites from the Moldanubicum and from the Alps. The zircons are exclusively inherited and show no new overgrowth after the deposition. On a Concordia diagram the high discordant points define straight lines which might be interpreted as mixing lines of more than 2000 m. y. old zircons with zircons formed at 560 m. y. or 410 m. y. respectively. The lower intersection with the Concordia may also indicate the weathering time of the former parent rocks. The zircons do not reflect a later influence during Variscan folding and slight metamorphism of the sandstones.

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B. GRAUERT, R. HÄNNY, and G. SOPTRAJANOVA

ISOTOPIC AGES OF PARAGNEISSES AND ANATECTIC ROCKS OF THE MOLDANUBICUM OF EASTERN BAVARIA

Rb-Sr whole rock and mineral measurements have been reported for some mica schists, quartzites, gneisses and calc-silicate layers from the Moldanubian crystalline complex of the Bavarian Forest. The obtained whole rock isochrons yield Cambrian to Ordovician ages and have low initial Sr^{87}/Sr^{86} ratios. These ages are interpreted as approximating the time of a first Sr isotope homogenization during a Prevariscan metamorphism probably with anatectic melting. Rb-Sr whole rock isochrons of partially molten paragneisses, however, gave Variscan ages and have higher initial Sr^{87}/Sr^{86}. A further anatexis at Variscan time is also supported by the U-Th-Pb isotopic relationships in concordant monazites and highly discordant zircon suites from the paragneisses and anatexites.

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B. GULSON (*)

AGE RELATIONS IN THE BERGELL REGION

Rb-Sr whole-rock analyses have been carried out on samples from units associated with the Bergell Massif in the South-Eastern Alps, i. e. the Tambo Nappe, Gruf migmatite complex, Bergell Massif and Novate granite.

In so far as the investigation has progressed, a number of facts may be stated with certainty :

a) The age of metamorphism of the rocks constituting the Tambo Nappe is 304 ($\pm$ 20) m. y. with an initial ratio of 0.707 ($\pm$ 0.004). Ages are calculated using

λ Rb $= 1.47 \times 10^{-10}$ yr.$^{-1}$ and Sr isotopic ratios are corrected to a value of 0.7080 for the E & A standard.

b) The Gruf migmatites definitely formed either prior to, or during, the Hercynian Orogeny and not the Alpine Orogeny as had previously been suggested. The migmatites are identical in age and initial $Sr/^{87}Sr^{86}$ to the Tambo rocks.

c) The Novate granite, the youngest phase of the Bergell Massif, has an age of 25 m. y. and initial ratio of 0.710.

d) Rb and Sr determinations by X-ray fluorescence spectroscopy on 185 rocks show the same Rb concentrations for the Tambo rocks and Bergell granites but with distinctly lower Sr concentrations for the Tambo samples. To form the Bergell granites by remelting of Tambo rocks thus necessitates introduction of Sr, not an unlikely possibility considering the presence of abundant carbonaceous material around the North East margins of the Bergell Massif.

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P. Horn, H. J. Lippolt and W. Todt (*)

Investigation of Ar-retentivities in basalts and their potassium rich xenoliths

A comparison of age measurements was made on basaltic whole rock samples, mineral separates of these basalts and on potassium rich xenoliths within the basalts. Four conclusions can be drawn from this work. 1) The approx. 320 my old granitic xenoliths which are thermally altered had been totally degassed at the time of their assimilation 60 my ago. 2). A thermally unaffected granitic xenolith found within the basaltic tuffs had suffered no argon loss after having been transported a distance of at least 1100 m through the volcanic pipe. 3) The whole rock ages of the fresh, glass-free basalts (nephelinites and a shonkinite) are 20 % lower compared to the ages measured on mineral separates (biotites, augites, nephelines) from the same rocks. 4) The potassium concentrations as measured on the whole rock samples agree within the limits of error with the calculated potassium contents derived from measurements on the constituent minerals. The measured argon-40 contents of the whole rock samples are 20 % lower than those calculated from the constituent minerals. This latter discrepancy is interpreted as the result of Ar^{40} loss from grains within the whole rock samples smaller than those used for mineral analyses, namely 10μm.

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J. C. Hunziker (*)

Rb-Sr and K-Ar Age determinations and the Alpine Tectonic History of the Western Alps

About 50 new Rb-Sr and K-Ar determinations on minerals and rocks are presented. The attempt is made to set up a time scale for the Alpine tectonics of the Western Alps using these data.

Two metamorphic phases can clearly be distinguished :

1. An early high pressure low temperature phase of upper Cretaceous age in blueschist facies and

2. a succeeding high pressure high temperature phase of about 40 m. y. in greenschist to amphibolite facies.

An attempt is made to incorporate the data into a model of global plate tectonics. According to this model a tectonic phase of Austroalpine elements overthrusting Pennine elements already in Upper Cretaceous time is postulated.

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E. JÄGER (*) A. K. BHANDARI (**) V. B. BHANOT (***)

Rb-Sr AGE DETERMINATIONS ON BIOTITES AND WHOLE ROCK SAMPLES FROM THE MANDI AND CHOR GRANITES HIMALAYA, HIMACHAL PRADESH, INDIA

Rb-Sr age determinations on biotite and total rock samples from the Mandi granite are presented. The biotite ages fall in the age range of 24-31 m. y. These ages represent the cooling time after the Himalayan metamorphism. Total rock isochron age of 500 m. y. was found for the Mandi granite. This is the first proof of rock formation in this age range in the Himalayan belt.

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V. A. KONONOVA, L. L. SHANIN, M. M. ARAKELIANTS (*)

TIME OF ALKALINE COMPLEXES AND CARBONATITES FORMATION (Based on the data obtained by K-Ar method)

In the course of geological development of separate regions of the U.S.S.R. alkaline complexes were emplaced repeatedly. The period of alkaline magmatism manifestation on the platforms is longer than in the folded areas.

Time of origin of alkaline complexes with different composition has been determined. The complexes of gabbro-alkaline rocks of the same age exist on the Baltic Shield and in the Altai-Sayany folded area, being 1900-1800 m. y. and 400 m. y.. respectively. In contradiction to that, complexes of ultra-basic alkaline rocks and carbonatites usually show different ages. The age of carbonatites on the Baltic Shield is 600 and 400 m. y. On the Siberian Platform their ages are estimated at 700, 600, 370 and 250 m. y. Carbonatite complexes older than 700 m. y. are unknown in the U.S.S.R.

Alkaline rocks proper were formed in the majority of the studied massifs during a short period of time with the exception of the Kovdor Massif where formation of alkaline rocks was going on with interruptions within an interval of 700-400 m. y.

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V. Köppel (*)

U-Pb mineral ages from the crust-mantle transition of the Ivrea and Ceneri zones, Southern Alps, Italy

Concordant U-Th-Pb ages of 270-300 my of monazite and xenotime from a paragneiss of upper amphibolite facies, from a migmatitic rock and from the post-metamorphic Mt Orfano granite determine either the time of mineral formation or the time when the U-Th-Pb systems in the minerals were closed.

The highly discordant age patterns of rounded zircons from granulite and amphibolite facies paragneiss point to an initial minimum age of the oldest population of 1900 my and to a lead loss 300 my ago which appears to have been more drastic in the granulite facies rocks (95-99 %) than in the amphibolite facies rocks (85 %). All zircons are similar with respect to their uranium contents, optical appearance and X-ray powder diffraction patterns.

In contrast, the mainly euhedral and uranium rich zircons from a migmatite have probably been formed 450 my ago inheriting approximately 1 % of an older radiogenic lead. Their U-Pb systems were either partially open until 300 my ago or they lost lead (10-50 %) at that time. Their X-ray powder diffraction pattern is more diffuse than those of the paragneiss zircons.

The zircons of the post-metamorphic Mt-Orfano granite yielded discordant ages pointing to an initial age of about 300 my and to a recent or continous lead loss.

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Ch. Kosztolanyi (*)

Lixivation studies of uraniferous minerals in relation with the geochronology of the deposits

Lixivation studies of one altered and one non altered pechblende sample by diluted acids and bases (N/10) and by double distilled water were carried out.

The aim of this study was to observe the modifications provoked by these lixivations on the chemical and isotopic composition of the percolated solutions and the residues.

The consequences of these lixivations on the geochronological results are the following :

1° In all the cases, augmentation of the discordance between three isotopic ages in the solution is a consequence of the increase of the ratio $^{207}Pb/^{206}Pb$. The $\frac{Pb}{U}$ ratio varies according to the nature of the percolating solution.

2° In the residues, the ages are more coherent because of the decrease of the ratio $^{207}Pb/^{206}Pb$.

3° Lixivation by successive fractions shows that the proportion of pechblende dissolved is higher in the first fraction; it diminishes rapidly with the second fraction and tends towards a constant value in the following fractions.

4° The isotopic composition of the Pb dissolved by the different fractions varies also from fraction to fraction. An important deficiency in ^{206}Pb is characteristic of the first fraction whose $^{207}Pb/^{206}Pb$ ratio is high; but this ratio diminishes regularly in the following fractions.

These experiments show that the chemical and isotopic composition of an uraniferous mineral is not homogeneous. The outer crust which is more soluble presents a composition which is clearly different from the rest of the mineral. This difference which manifests itself in the form of a deficiency of ^{206} Pb is higher when the mineral is more altered.

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K. O. Kratz, S. B. Lobach-Zhuchenko (*)

Geochronological Boundaries and Geological evolution of the baltic shield

The development of vast mobile areas in the Early Precambrian of the Baltic Shield culminated resulting in the stabilisation and following extensive regional regeneration of the plutonic and plutonic processes at a period 2700-2600 m. y. and at a period 1800 m. y. ago.

Within the continental massif of the Late Precambrian similar regeneration took place along limited superimposed belts at a period 1000-900 m. y. ago.

Similar type of development seems to have taken place in the Precambrian of Canada, Guiana, South Africa and Australia with same age boundaries of regeneration. Besides such global boundaries, other age boundaries indicate only local geological phenomena, which differ for different regions.

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S. B. Lobach-Zhuchenko, E. K. Gerling, T. V. Kolzova (*)

K-Ar geochronology of the Baltic Shield

Interpreting K-Ar data ages of micas as indicators of different geological events : metamorphism-plutonism, time of block movements, time of secondary heating and related activation was taken into consideration.

For the Baltic Shield it is possible to discern the following stages of metamorphism and plutonism : $\rightarrow$ 3300, 3000, 2700-2500, 2300-2200, 1900-1800 ; 1000-900 m.y. Analysis of the geology and isotopic data shows the polimetamorphic character of the greatest part of the Precambrian terrane.

The areal distribution K-Ar data of the platform period of the Baltic Shield in the rocks of the basement characterize the block structure of the Shield for this time.

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R. M. MACINTYRE (*) and J. B. DAWSON (**)

RADIOMETRIC DATING OF ALKALINE INTRUSIVES IN SOUTHERN AFRICA

The ancient crust of the Southern part of the African continent has been pervaded by a number of alkaline complexes whose age cannot be determined with any certainty from the geological evidence. However the occurrences comprise a variety of rock types containing potassic minerals, and these can be dated by the potassium-argon method.

A geochronological study has been commenced on the alkaline igneous complexes at Spitzkop and at Palabora. Potassium-argon measurements have been performed on mineral separates from a number of rock types including syenite, nepheline syenite, ijolite, melteigite, umptekite, pyroxenite and aegirine and micro-ijolite veins. The preliminary results suggest a prolonged but rather contemporaneous sequence of events at both centres, with disturbances dated at 1300 m. y., 840 m. y. and possibly also 1050 m. y. and 620 m. y.

These measurements suggest that excess argon may be found in phlogopite and potassium feldspar, and, when combined with other geochronological evidence, indicate that activation of alkalic intrusive centres occurred at a number of localities around 1300 m. y. in Southern Africa,

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H. MALUSKI (*)

Rb-Sr GEOCHRONOLOGY OF THE MASSIF DES MAURES (FRANCE)

The Maures mountains in the South-Eastern France, between the Mediterranean Sea and the Secondary sediments of Provence are an example of polyphased tectonic range. Metamorphism wholly affects them. It is growing from West to East.

Three tectonic Hercynian phases worked there :

- Phase 1 : N — S isoclinal folding together with intense flow cleavage. Structures of this phase are overflown to West.
- Phase 2 : N — S as well resulting in more open folds together with strain-slip cleavage in the West and causing foliation visible in gneiss. Structures of this phase are overflown to East.
- Phase 3 : Less important than the previous ones and causing a network of Kinks.

This mountain during the « Pyreneo-Provençale » Phase was affected by a tectonic with brittle effect resulting in the faults running E-W through the mass.

Geochronological studies deal with the gneiss mass of Bormes in an anticlinal situation (phase 2), in the central Southern part of range and the granites of Plan de la Tour intrusive in the Eastern migmatites. Whole rock gneiss analyses show two ages, corresponding to two series distinct as for petrography : 550 MY for orthogneiss, 430 MY for paragneiss. These ages suggest a Prehercynian history of these rocks.

Hercynian metamorphism is apparent from mineral analyses that give isochrons whose slopes correspond to ages ranging between 310 and 270 MY. Some apparent ages from biotites give 60 MY.

The granites of Plan de la Tour which, though regarded by the authors as being post tectonic, show an age of 320 $\pm$ 15 MY.

The ages of the minerals of this granite is 300 MY.

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D. Menagh, T. J. S. Cole, W. Armbruster (*)

Rb-Sr Mass spectrometry with an on-line PDP II

The system is based on an ASR 33 teletype and standard digital logic. It has been expanded in easy stages to full on-line control and analysis with a small computer. The original hard-wired system remains fully operational and available for use at any stage.

Stage (1) : A hard-wired system of K-series digital logic units timed by the 220 Hz clock of the ASR 33 steps the magnetic field and records one ion current in two seconds. The data tape is processed elsewhere.

Stage (2) : The data output is interfaced to the PDP II computer, while the hard-wired logic still controls the operation. Data analysis and tail analysis are done on-line using a BASIC programme.

Stage (3) : The magnetic field and the accelerating voltage are now interfaced. Keyboard command selects the required mass over a range of 4 mass units to within 10^{-3} mass units. The computer is acting inside the feedback control loop of the magnetic field via the necessary D/A and A/D converters. Similarly the ion accelerating voltage is controlled over a range of $\pm$ 200 volts for tuning, baseline, etc. BASIC programming is used. Preliminary results indicate that about 15 minutes on line will give a standard deviation of the mean of about 0.03 % to 0.003 % of $(Sr^{87}/Sr^{86})_N$ depending on the ion current magnitude.

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R. Montigny (*)

Sr^{87}/Sr^{86}, K, Rb, Ba and rare earth elements in an ophiolitic complex. comparaison with abyssal basalts

The Pinde complex is a typical ophiolitic suite with the following sequence of unmetamorphosed rocks : pyroxenites, peridotites, gabbros, dolerites and albitophyres. Sr^{87}/Sr^{86} ratios are fairly low throughout most of the series, (0.705) with the exception of the albitophyres which are higher, (0.706). The higher values are possibly the result of a contamination. K/Rb values range from 300 to 3000. K versus Rb diagram in log scale indicates that the gabbros and the albitophyres give an evolution trend similar to the one yielded by basalts from the Puerto Rico Trench, analysed by S. Hart.

Rare earth data give a flat pattern very similar to that of abyssal tholeites but with some europium (positive and negative) anomalies.

Except the $^{87}Sr/^{86}Sr$ ratio, all results are similar to abyssal basalt results.

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S. Moorbath and H. Welke (*)

Strontium and Lead Isotope Studies on Composite Acid-Basic Dykes and other Igneous Rocks of lower Tertiary Age from the Isle of Arran, West Scotland

Initial strontium and lead isotopic compositions of acid members of composite dykes are found to be quite different, and generally more radiogenic, than those of the basic members, indicating that they are probably not directly genetically related. However, there is also considerable variability in isotopic composition between similar rock types in different intrusions within the area, whether composite or not.

The factors that govern initial strontium and lead isotope compositions are numerous and complex, so that conventional point-by-point interpretation of isotope ratios in terms of simple petrogenetic models is difficult or impossible in this type of area. Nevertheless there is a broad general relationship between isotopic compositions of the igneous rocks and of the country rocks which, in this case, consist of Late Precambrian and Lower Palaeozoic metasediments (Dalradian Series) extending to considerable depths. The situation in Arran will be compared and contrasted with published results from the Lower Tertiary acid and basic igneous rocks of the Isle of Skye, Northwest Scotland, West of the Moine thrust, where the sub-surface country rocks consist of ancient Precambrian basement gneisses (Lewisian).

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G. Noiret (*)

Rb^{87}-Sr^{87} Geochronology of basement complex of Bassin de Paris

Some basement rocks sampled by coring are studied by $^{87}Rb/^{87}Sr$ method both in whole rocks and mineral separate.

The total rocks isochron gives an age of 420-550 m y and the mineral isochron indicates a Hercynian age of 300 m y.

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P. Pasteels (*) and S. Deutsch (**)

Interpretation of discordant ages of Zircons in relation with their Uranium content

A certain number of zircon suites defining true or approximate linear arrays on the Concordia diagram are studied, in order to examine the mechanism of disturbance.

A broad similitude of behaviour is observed in different cases of zircon suites whatever the age of their respective upper and lower intercepts. The latter cannot be predicted from consideration of the former.

The uranium content corresponding to a given amount of disturbance is very different from that which is predicted by the continuous diffusion model with linear buildup of radiation damage. Also, the considered cases do not correspond to the mixture of a highly discordant and a nearly concordant phase.

It seems that the best fitting model is that of episodical lead escape, promoted either by metamorphism or by ground-water leaching (dilatancy effet). A multiple stage history must be considered in some instances, to account for the value of the lower intercept of the chord with the Concordia curve, and for the fact that the experimental points sometimes define a smooth curve rather than a straight line.

Assuming that the lead loss occurs during a relatively short time-span and the escape constant is proportional to the uranium content (or to U + 0,23 Th), the merits of first order and second order kinetic laws are considered in turn. Unexpectedly, the second order law yields a rather satisfactory agreement with the data in most cases.

This model however rests on very crude assumptions and at best, it only gives a semi-quantitative insight of the actual situation. The rate of lead escape probably depends on the degree of hydratation, content of accessory elements, radiation damage.

The presence of more than one generation of zircon as well as uranium loss must be considered, in some cases, as probable interfering phenomena.

This work is part of the programme of the Belgian Centre for Geochronology.

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P. Pasteels and J. Michot (*)

U-Pb isotopic ages in the metamorphic terrane of Rogaland and Vest-Agder S. W. Norway

The results of 45 isotopic age determinations performed on zircon, sphene, monazite, allanite are summarized and the main conclusions drawn. These data are supplemented by some Rb/Sr determinations.

From a geological point of view, the main conclusions are the following :

a) In central Rogaland, an almandine-amphibolite facies metamorphism accompanied by migmatitisation can be dated at 975 m. y. ago.

b) In South Rogaland, metamorphism in granulite facies conditions occurred or ended 970 m. y. ago and folding with steep axial planes took place. At the same time were emplaced a charnockitic adamellite body (Sjelset) and the ultimate, mangeritic phase of the South Rogaland Igneous Complex, which consists principally of associated anorthosites, leuconorites and norites, emplaced or formed in situ at several different times. There is in the same region a strong indication of the existence of a significantly older tectonic phase, with piling up of recumbent folds, 1200 to 1300 m. y. ago. However the age of the first, mainly anorthositic phase of the South Rogaland Igneous Complex remains undetermined.

c) In Vest-Agder, the late-cinematic « farsundite » body, charnockitic to the West, presumably related to anorthosite, was emplaced 1000 to 970 m. y. ago. Migmatitisation appears to have occurred 1035 m. y. ago, thus somewhat earli erthan in Rogaland.

A 1500 m. y. figure can be extrapolated for a zircon suite extracted from an amphibolite-facies aplitic gneiss. This value points either to the age of the detritic component or, more probably, to that of geosynclinal magmatism.

Some conclusions can also be drawn concerning the possibilities and limitations of the uranium-lead method for deciphering a complicated metamorphic history of which the investigated case is an example. Detritic zircon is not wholly reset to zero in granulite facies conditions, except, possibly, in migmatites. Cases of spurious extrapolated zircon ages (upper intercepts) seem to exist.

This work is part of the programme of the Belgian Center for Geochronology.

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R. T. Pidgeon and M. Aftalion (*)

The significance of U-Pb ages of oval zircons from a Lewisian gneiss, Harris, Outer Hebrides

The presence of oval shaped zircons in gneisses of uncertain origin can be taken as evidence for a sedimentary history for the rock. Such zircons could come from a number of sources and the isotopic relationships of the composite zircon population could reflect a random mixture of the contributing zircon populations.

However the U-Pb isotopic analyses of five fractions of a population of oval zircons from a single block sample of Archaean Lewisian gneiss have discordant apparent ages which show a linear trend on a concordia plot intersecting the concordia at 2,770 m. y. and 1,730 m. y. Using a model of episodic isotopic disturbance in conjunction with geological and geochronological evidence. the intersections with concordia are interpreted as the ages of actual geological events rather than as apparent ages resulting from the random mixing of zircon populations of different ages and discordance trends. On the basis of detailed morphological considerations it is suggested that the zircons mainly originated during the major metamorphism of the Scourian orogenic episode.

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G. S. Plyusnin, V. S. Lepin, B. P. Sanin, S. B. Brandt (*)

Age and regularities in isotopic abundances of ore leads of eastern Transbaikalia

An investigation of isotopic abundances of ore leads from polymetallic ore deposits of Eastern Transbaikalia permitted to distinguish leads of the B-type and J-type.

Variations models of generation of these ores are considered. Isotopic data justify the assumption of sources of ore substance connected for some deposits with a granitic magma and for others with differentiates of gabbroid magma, depending on different paths of the migration of the leads to the deposits.

A definite correlation between isotopic abundances of ore leads and the concentration of the trace and rare elements in them. The latter circumstance confirms the fact that the variation of isotopic abundances of the lead has taken place due to a mixing of primary ore leads with leads enriched by radiogenic isotopes. The age of the deposits is estimated at 150 m. y.

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Thermal and tectonic history investigations by K-Ar dating in the southern branch of the Romanian Carpathians

The new K-Ar ages obtained in the Southern branch of the Romanian Carpathians between the river Olt and the Danube are presented. The area is made up of mesometamorphic and epimetamorphic rocks the latter being intruded by numerous granitoids. It is considered that the mesometamorphic rocks represent a nappe covering the Danubian Autochthonous which defines the area formed of epimetamorphic rocks and granitoid intrusions.

From all the available K-Ar ages the following conclusions can be drawn :

1) The Susita and Tismana granitoids intruded in the Danubian Autochtonous South of an important fault fracturing all the Autochtonous from NE to SW are emplaced during the Assyntic orogeny.

2) All the rocks North of this important fault have suffered during the Hercynian orogeny a strong thermal event which less affected the compartment South of the fault. In this compartment a slight gneissic texture was overprinted to an important zone of massive Susita granitoids.

3) All the Danubian Autochtonous suffered an Alpine thermal event which completely expelled the radiogenic argon from the sericitic schists and argillites.

4) The K-Ar ages of the mesozonal rocks date times of uplift and cooling of these rocks. The relations between mesozonal and epizonal rocks started to be outlined during the Hercynian orogeny and further developed during the Alpine orogeny.

If the Danubian Autochtonous was really overriden by the large Getic Nappe during the Alpine orogeny, it is difficult to explain how assyntic or hercynian K-Ar ages which on geological grounds can be considered as absolute ages could be preserved.

It is possible to explain the relations between mesozonal and epizonal rocks otherwise than by a large Nappe if the mesozonal rocks are considered to be blocks having emerged from the basement. In this case the granitoids with assyntic K-Ar ages were never buried under a cover of rocks 6.000 m thick.

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H. N. A. Priem, N. A. I. M. Boelrijk, E. H. Hebeda, E. A. Th. Verdurmen and R. H. Verschure (*)

Isotope geochronology in Suriname (Guiana Shield, South America)

Since 1965 the Amsterdam Z. W. O. Laboratory of Isotope Geology has been engaged in an extensive dating programme of the Precambrian and crystalline rocks in Suriname, in close co-operation with the Government Geological & Mining Service (G. M. D.). The crystalline basement of the territory forms part of the Guiana Shield, a Precambrian craton covering more than 1.5 sq km and forming the nucleus of the north-eastern part of South America. Shield rocks occupy roughly 80 % of Suriname, Only some 250 sq km in the central part of the country (the Tafelberg area) are overlain by the Precambrian Roraima Formation, while in a relatively narrow zone along the Atlantic coast the basement is covered by series of younger sediments (Upper Cretaceous to Recent). Moreover, the Precambrian rocks contain many gabbroic-doleritic dikes and sills.

From the Rb-Sr and K-Ar data obtained so far, the following geological events can be distinguished, in part as yet tentatively (all errors quoted with 95 % confidence level as calculated from the analytical data; $\lambda\,^{87}Rb = 1.47 \times 10^{-11}$/yr; $^{40}K = 0.0118$ atom % total K, $\lambda e = 5.85 \times 10^{-11}$/yr, $\lambda\beta = 4.72 \times 10^{-10}$/yr) :

I. Intrusions of swarms of NNW-SSE trending dikes of pigeonite dolerite were dated by K-Ar measurements at 227 $\pm$ 10 m. y. (Permo-Triassic). Evidently, this basaltic magmatism was related to the beginning of the Atlantic rift.

II. Nickerie Metamorphic Episode in western Suriname about 1200 $\pm$ 100 m. y. ago. This tectonothermal event, recognized by wide-spread «updating» of micas in the basement rocks, was associated with transcurrent faulting movements, the rise of horsts of deep-crustal rocks, and the emplacement of huge masses of peridotite.

III. Intrusions of doleritic-gabbroic masses (hypersthene-bearing pigeonite dolerite and gabbro) between 1500 and 1800 m. y. ago. These masses, which are mainly confined to the western part of the country, are often characterized by large amounts of excess argon, probably introduced into the rocks from the degassing basement during the Nickerie Metamorphic Episode. Dating by means of K-Ar measurements is, therefore, very difficult. From the presently available data, also taking into account paleomagnetic measurements, it may be inferred that there were two periods of intrusions, one between 1500 and 1650 m. y. ago and the other at around 1750 m. y. ago.

IV. Deposition of the Roraima Formation. Rb-Sr and K-Ar dating of one sample from an intercalated ignimbritic layer produced concordant ages around 1610 m. y.

V. Trans-Amazonian orogeny, characterized by wide-spread plutono-volcanic magmatism, folding movements and metamorphism. The granitoid rocks and acidic volcanics belonging to this period of magmatism occupy the greater part of Suriname and were dated by means of a Rb-Sr whole-rocks isochron at 1810 $\pm$ 40 m. y. Among the granitoid masses, syn-tectonic and post-tectonic intrusions can be distinguished.

The Trans-Amazonian Orogenic Cycle is an important event of folding, metamorphism and granitoid magmatism in the whole of eastern South America. It can be correlated with the Eburnian Orogeny in Africa.

VI. Geosynclinal deposition of sedimentary-volcanic sequences, later folded and regional-metamorphosed by the Trans-Amazonian Orogeny, as well as intruded

and contact,metamorphosed by the Trans-Amazonian granitoid masses. A few age measurements on volcanic rocks suggest that these deposits represent the earlier geocynclinal stage of the Trans-Amazonian Orogenic Cycle.

VII. The horsts in western Suriname risen during the Nickerie Metamorphic Episodes are made of high-grade metamorphic rocks of deep-crustal origin (charnockites, granulites and high-grade gneisses). No age measurements have as yet been made on these rocks, but a few age measurements on similar rocks in Guyana and Venezuela suggest that they represent events of metamorphism and granitoid magmatism much older than the Trans-Amazonian Orogeny.

Much more dating work in Suriname is in progress.

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G. M. Reimer and G. A. Wagner (*)

Fission-track Studies of Alpine Epidotes and Garnets

Epidote and garnet from about 20 localities from the Central and Southern Alps in Switzerland and Italy were studied using the fission-track method.

Epidote fission-track ages range from 3-16 m. y. and are generally older than the fission-track apatite ages and younger than Rb/Sr biotite ages of the same rock samples. These ages are interpreted as cooling ages rather than original formation ages.

The low uranium content of the garnets, mostly less than 0.2 ppm, is a prohibiting factor in their use for fission-track age studies in the Alps.

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M. Rubinstein, Sh. Adamia, D. Devnosaschvili, V. Dobridin, L. Rosentur (*)

Dating of some Late Neogene and Quaternary effusives of Transcaucasia (based on geological, radiological and paleomagnetic data)

Well stratified lava deposits of Southern Georgia, interbedded by lacustrine, fluvial and deluvial deposits, which in some localities contains mammalian faunas of Late Pliocene to Middle-Late Pleistocene ages, represent a suitable object for a combined use of both the argon and paleomagnetic dating methods.

The argon ages of andesite-dacites, dolerites and andesite-basalts, varying from 0,37 to 2,36 m. y., when correlated to the vectors of residual magnetic field and biostratigraphical data, allow to estimate the absolute age of the recent inversion of the magnetic field (the Brunes-Matuyama boundary) as 0,6-0.7 m. y., in good agreement with the magnetic-chronological scale proposed by Cox.

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M. Roques (*), M. Vachette (*), Y. Vialette (*), J. Bernard-Griffiths (*), J.-M. Cantagrel (*), J.-L. Duthou (*)

Géochronologie du Socle du Massif central

Cette étude est surtout basée sur des déterminations d'âge par la méthode au strontium par isochrones sur roches totales. Elle débute par un bref rappel des critères qui ont servi à l'interprétation des âges suivi de l'échelle des temps géologiques pour le Paléozoïque et des mesures retenues dans le massif Central pour son établissement.

Échelle géochronologique du paléozoique : *Tufs dacitiques, Viséen supérieur* : Les micas et isochrones de roches totales ont donné les résultats suivants : Bassin de l'Ardoisière (328 $\pm$ 5 M. A.), Bassin de Manzat (330 $\pm$ 6 M. A.), Bassin de Châteauneuf-les-Bains (328$\pm$7 M.A.), Bassin de St-Honoré-les-Bains (329$\pm$10 M.A.).

Formations volcaniques du Stéphanien — Les gores du Stéphanien B de Saint-Étienne ont donné 289 $\pm$ 18 M. A La base du Stéphanien B de Brassac-les-Mines a été datée à 288 $\pm$ 8 M. A.

Les isochrones déterminées sur roches totales ont permis de rapporter les formations cristallines et cristallophylliennes aux cycles suivants :

Ages Cadomiens : (anté 570 M. A.) : Migmatites type anatexite d'Aubusson du noyau Lémovico-Arverne : Aubusson (668 $\pm$ 25 M. A.), Moyenne Dordogne (647 $\pm$ 30 M. A.). Mise en place probable du granite du Mendic (Montagne Noire) remobilisé au Calédonien (453 M. A.) et à l'Hercynien (300 M. A.).

Ages Calédoniens (570 — 395 M. A.) : *Schistes cristallins d'âges Cambriens* : Migmatites stratoïdes et gneiss de la Moyenne Dordogne (540 $\pm$ 35 M. A.), Embréchite de Tulle (526 $\pm$ 26 M. A.), Anatexite schisteuse du Haut-Allier (526 $\pm$ 44 M. A.).

Schistes cristallins d'âges Ordoviciens et Siluriens : Migmatites stratoïdes d'Yzeron (Lyonnais) (493 $\pm$ 15 M. A.), Migmatites du Centre du Velay (477 $\pm$ 27 M. A.), Leptynite du Haut Allier (470 $\pm$ 8 M. A.), Gneiss œillés de la Vallée du Lot et Gneiss à amphibole (435 $\pm$ 21 M. A.). En Montagne Noire la migmatisation de la zone axiale a débuté à 475 $\pm$ 27 M. A. (anatexites de la Montagne d'Arêt). Cet âge a été conservé dans une amphibole de l'Ouest de la Montagne Noire. Des âges à 438 $\pm$ 20 M. A. (embréchite d'Héric) et 419 $\pm$ 20 M. A. (Anatexite d'Agoudet) ont également été mesurés dans la zone axiale. Dans le Haut Allier les anatexites à faciès Vauclair ondonné un âge de 412 $\pm$ 27 M. A. Dans le noyau Lemovico-Arverne et les chaînes péri) phériques, les micaschistes ont donné le même age à Buissière Poitevine (Limousint (397 M. A.) en Moyenne Dordogne (397 $\pm$ 3 M. A.) et en Montagne Noire (413 $\pm$ 20 M. A.). Sont actuellement en cours d'étude et fournissent sensiblement les mêmes

âges : les micaschistes de la région de Tulle, ceux de la bordure sud du Massif du Velay, les micaschistes du Pilat et ceux du Rouergue.

Granites : mise en place des granites de Château-Gaillard près de Thiers (Puy-de-Dôme) (506 ± 18 M. A.), de la Margeride (401 ± 24 M. A.) de l'Aigoual (412 ± 29 M. A.). Remobilisation du granite du Mendic à 453 ± 21 M. A.

Ages Hercyniens (395 — 225 M. A.) — *Mise en place de granites* : Granite du Velay (395 ± 22 M. A.), première venue de leucogranites de la Margeride (370 ± 13 M. A.), granite d'Issy Levêque, Morvan (350 ± 31 M. A.), granite de Tronçais (347 ± 9 M. A.), granite de Gien-sur-Cure (335 ± 7 M. A.), granophyre de Thiers (325 ± 18 M. A.), granite de Cornil (317 ± 15 M. A.), granite du Folat dans la Montagne Noire (320 M. A.), leucogranite de Cérilly (286 ± 11 M. A.), 2me venue de leucogranites de la Margeride (283 ± 4 M. A.).

Métamorphisme hercynien : Plusieurs groupes d'âges hercyniens ont été mis en évidence par isochrones sur roches totales : à 385 M. A. reprise probable des anatexites à cordiérite du Haut Allier, et à 283 ± 26 M. A. mobilisation des anatexites du cœur de la zone axiale de la Montagne Noire.

D'autres âges hercyniens ont été trouvés pour des isochrones sur minéraux : embréchites de Tulle (337 ± 8 M. A.), gneiss de la Vallée du Lot (320 — 360 M. A.) et migmatites de la bordure de la zone axiale de la Montagne Noire (280 — 320 M. A.). Tous ces gneiss ont donné des âges calédoniens par isochrones sur roches totales.

C'est aussi le cas pour le granite du Mendic dans la Montagne Noire (isochrone sur roches totales à 453 M. A. et isochrone sur minéraux à 300 M. A.) et pour le granite de Châteaugaillard ,près de Thiers (isochrone sur roche totale à 506 M. A et isochrone sur minéraux à 312 ± 13 M. A.).

De nombreux autres granites ont donné des âges hercyniens par isochrones sur minéraux, sans isochrones sur roches totales disponibles, de sorte qu'il n'est actuellement pas possible de savoir si l'âge est celui de la mise en place ou celui d'un rajeunissement. C'est le cas dans le Charollais pour le granite de Dompierre (320 ± 12 M.A.) et dans le Limousin pour les granites de Vaulry (344 ± 9 M.A.), Aureil (323 ± 7 M.A.), Chirac (310 ± 9 M.A.), Cieux (300 ± 7 M.A.), Saint Mathieu (300 M.A.), Cognac (295 M.A.), Saint Sylvestre (294 M.A.), Châteauponsac (284 M.A.) et la Brame (284 M.A.).

Enfin, toutes les biotites du socle du Massif Central ont donné des âges hercyniens, avec deux maxima de fréquences, l'un à 335 M.A. (Lacune Tournaisienne), l'autre à 300 M.A. (soulèvement asturien).

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M. Rubinstein, L. Gabunia (*)

Some problems of geochronology of the Cenozoic

In 1964-1965 we proposed a correlation scheme of the Cenozoic of Eurasia and North America, based on the combined use of geochronometrical and biostratigraphical (mainly mammalogical) date.

A revision of this scheme, stimulated by the appearence of new data, supports the formerly suggested ages for the majority of boundaries in the Cenozoic. Special complications are associated with the radiological dating of the traditional Miocene-Pliocene boundary, so far as the last turned out to be asynchronous in different regions (in particular 6.5 m. y. for Mediterranean bassin, 9 m. y. for Black Sea-Caspian basin, 13 m. y. for North America). Hence, a necessity arises to revise the stratigraphical nomenclature of the Neogene.

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N. P. Semenenko (*)

Geochronological map of crystalline basement in the South-West part of East-European platform and its folded frame

The most ancient Dnieper platform is the important geological structure of the Ukrainian shield. It is composed of folded formations the age of which is 2700-3500 m. y.

There are two platforms that had been stabilised 2000 m. y. ago. These are : Buzhsko-Podolskaya composed of formations the age of which is 2000-2700 m. y. and Dneprovskaya-West Pryazovskaya (2000-3500 m. y.).

In the late Pre-Cambrian II (1700 m. y.) the great bulk of Ukrainian shield, Voronezhsky massif and Mysian platform in the Balkans had been stabilised.

The stabilisation of the folded belt of the Ovruch-Volyn region (1200-1700 m. y.) had been completed by the forming of East-European platform.

The platform is edged with folded formations of Pre-Cambrian V megacycle (1100-550 m. y.) from the West and the South.

The Galithian belt being the basement of Carpathians separate the Ukrainian shield from Mysian platform. Here two structures are distinguished the belt of Blacksea cycle of folding (1100-700 m. y.) and the belt of Rachov cycle of Galithian folding the age of which is 700-550 m. y. They appear in the basement of Carpathians, Balkans and Dinarides.

The phases of folding and metamorphism are distinguished :

Caledonian : ancient-Caledonian (Sandomyr-Dobrudgian) — 475-550 m. y.; middle-Caledonian (425-470 m. y.) and late-Caledonian — 480-420 m. y.

Hercynian : ancient-Hercynian (330-360 m. y.), middle-Hercynian (270-330 m.y.) and late-Hercynian (240-270 m. y.).

Alpine-Mesozoic phase — 100-220 m. y. and young-alpine postlaramian — in the period of time 10-100 m. y.

The oldest formation in the region of the Dniepr platform (Korkskaya series) of an age of 3000-3500 M. Y. are represented in syncline slightly metamorphosed and composed by phyllitic facies which contains :

1) sands and clays sediments

2) volcanic acidic and basic rocks

3) iron cherts sediments.

From these observations, one may conclude the following :

1) the character of weathering occuring 3500 M. A. ago are much the same as those of recent time erosion where clays and sands were sedimentated.

2) the atmosphere of that time contained free oxygen as shown by the oxydized iron facies

3) the oldest layers of the Earth crust contain quartz. That means that there is no proof of the existence of a primordial basaltic layer. This first crust must have had a distinct granitoid composition

4) the variety of these very old formation is typical of a geosyncline. One finds acidic effusive rocks

5) folding had a linear character just like it happened during more recent times.

It is known that the Eastern European plateform was accreted by the addition of stabilized regions formed during the megacycles I, II, III and IV, and that its stabilisation ended 1200 M. Y. ago. Since that time in Europe at the West from the European plateform, the Precambrian basement remained mobile and geosynclinal belts passing through the platform during Precambrian and Phanerozoic can be observed.

Rumanian geologists (GUSKA and others) concluded that, in their region, before 1200 M. Y. existed an oceanic crust. The continental crust began to form during Precambrian V, that is 1200 M. Y. ago. We do not agree with this point of view because one knows very old formations in Scotland and in the Mysysky plateform in the Balkans. One also knows detrital zircons in the Paleozoic gneisses of the Alps with an age of 1800 M. Y. Without any doubts, there are discrepancies of stabilized Precambrian structures appearing as central massifs of Pamir and in the Alps.

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N. P. SHCHERBAK, E. N. BARTNITSKY, G. D. ELISEEVA. (*)

THE GEOCHRONOLOGICAL SUBDIVISION OF GRANITES OF THE UKRAINIAN SHIELD

The comparative study of Pre-Cambrian granitoids of the Ukrainian shield using geological and radiological criteria is carried out.

The spatial and genetic relation of the granites from complexes of different ages with specific series of metamorphic rocks is established.

It is shown that Archean granitoids of the Dnieperovsky complex represented by granodiorites, plagiogranites and aplitic-pegmatoidal granites are spread in the Middle Pridnieperovie and West part of the shield. The substratum for them were supracrustal formations of the Konksko-Verkhovcevsky and the Dniesterovsky-Bugsky series. The absolute age of the granitoids of this complex obtained on the accessory minerals and amphiboles is 2500-2800 million years.

The Proterozoic granites in the Pre-Cambrian of the Ukrainian shield spread wider. The granites of the Berditchevsky-Pobugsky and Kirovogradsky-Jitomirsky complexes predominate among them. These granites have been formed within ranges of 2300-2100, 2100-2000 and 2000-1800 m. y. accordingly. The enclosing rocks for the Proterozoic granites are the metamorphic rocks of the Teterevskaya, Krivorogskaya and Ingulo-Ingulstskaya series.

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M. Soroiu and G. Popescu (*)

A new method for potassium determination by neutron activation in mineral and rock samples

For potassium determination by neutron activation, the reaction $K^{39}(n, p)^{39}Ar$ is used. Depending on their potassium content, samples of 100 or 200 milligrams are being irradiated during 40 hours at a flux of 5.10^{12} fast neutrons and 10^{13} thermal neutrons/cm^2. sec. Quantities of 100 milligrams of potassium bichromate are used as standards. Both samples and standards are introduced into small cylindrical packets made of aluminium foil. These packets are placed in tubes also made of aluminium foil. At the ends and the center of each tube, there are $K_2Cr_2O_7$ standards for ensuring a precise knowledge of the vertical flux variation. Up to 12 tubes containing 50-70 samples are vertically disposed on a circumference by means of a support and simultaneously irradiated. The irradiated samples are melted in vacuo in steel crucibles at 900°C- borax being used as a flux. The gases released during the melting react with titanium used as a gettering material. ^{39}Ar and the other gases which have not been eliminated by titanium are collected in glass vials by adsorbtion on charcoal at liquid nitrogen temperature.

The vials are opened in a Toepler pump by means of which the gases from the vials are pumped around a Geiger counter for beta particles. ^{37}Ar produced by the reaction ^{40}Ca (n, α)^{37} Ar and ^{133}Xe that appeared by the fission of ^{235}U may interfere when measuring ^{39}Ar activity. Methods for eliminating these interferences have been worked out. By comparing the potassium contents determined by classical and by neutron activation methods on 12 different mineral samples, the conclusion can be drawn that the precision and the accuracy of the new method are better than $\pm$ 3 %.

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W. Todt and H. J. Lippolt (*)

Potassium-argon age determinations of Miocene rocks with known paleomagnetic parameters

Potassium argon determinations were carried out on about forty volcanic rocks of Miocene age from several volcanic areas in central Europe (Lausitz, Oberpfalz, Eifel, Westerwald, Siebengebirge). The paleomagnetic parameters of the rocks selected for analyses are known from literature. The ages found lie between 13 and 28 my. 25 rocks were normally and 18 inversly magnetised. The age data and the paleomagnetic data can be used for an approach to a paleomagnetic scale for the Miocene time. Ten reversals of the magnetic field could be distinguished for the given time interval.

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A. I. Tugarinov, E. V. Bibicova (*)

Geochronological events in the pre-cambrian history of the eastern part of the Baltic Shield by Pb-U-Th method

The detailed investigation of radiometric age by Pb-U-Th method of accessory minerals (zircon, monazite) from different magmatic and metamorphic rocks of the

Eastern part of the Baltic Shield permits to distinguish in its Pre-Cambrian history several geochronological events :

2750 ± 100 m. y. ago — ancient granite magmatism of Kola and Karelian regions; the regional metamorphism of Belomorian and Kola gneisses.

2450 ± 50 m. y. ago — intrusion of deep-seated granites-charnokites in the joint zone of Belomorian and Karelian formations.

1900 ± 100 m. y. ago — formation of granulites and Belomorian pegmatites-alkaline granites of Kola region, the second stage of regional metamorphism of Belomorian and Kola gneisses.

1550 ± 50 m. y. ago — formation of rapakiwi granites of the platformian type.

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O. van Breemen (*), J. H. Allaart (**) and M. Aftalion (*)

Rb-Sr and U-Pb zircon age work on granites from the Ketilidian mobile belt (early Proterozoic), South Greenland

Within the Ketilidian mobile belt (early Proterozoic) of South Greenland material has been collected of gneissose granites and late or post tectonic granites including rapakivi granite. The post tectonic granites intrude supracrustal rocks (Tasermiut fjord) which were deposited, either during the late Archaean or the early Proterozoic. The whole rock Rb-Sr and U-Pb zircon analyses on the collected material indicate that Ketilidian granite activity has been concentrated around 1800 m. y. This supports the idea that there is no important break during the Ketilidian plutonic development in the mobile belt.

The samples give no isotopic evidence for the presence of a pre-Ketilidian basement. This is interpreted as reflecting the high intensity of Ketilidian plutonism particularly in the areas of more homogeneous granites from which the samples were collected.

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R. H. Verschure (*), N. A. I. M. Boelrijk (*), E. H. Bon (**), E. H. Hebeda (*), H. N. A. Priem (*) and E. A. Th. Verdurmen (*)

Isotopic geochronology in the precambrian tin district of Rondonia, Western brazil

The Older Basement of the cratonic area of Rondônia (amphibolites, gneisses) has been intruded by the Older Granites (syn-tectonic ?). So far, only a few isolated hornblende K-Ar and biotite Rb-Sr/K-Ar ages of the Older Basement are available, and a single whole-rock Rb-Ar age of an Older Granite. If these isolated data have any meaning, then they suggest that metamorphism and the emplacement of the Older Granites in the Older Basement occurred some 1250 to 1300 m. y. ago. Locally, these rocks are overlain by low-grade metamorphic sediments (mainly sandstones) of

uncertain age and stratigraphic position. All these units have been intruded by small plutono-volcanic bodies (possibly sub-volcanic ring-complexes) of mainly acidic composition, associated with important tin mineralizations. K-Ar biotite dates and a Rb-Sr whole-rock/biotite isochron indicates an age of 980 $\pm$ 20 m. y. for this younger magmatic event, which, according to structural relationships and chemical composition, seems to be of anorogenic nature. (Error with 95 % confidence level as calculated from the analytical data; $\lambda\ ^{87}Rb = 1.47 \times 10^{-11}$/yr; $^{40}K = 0.0118$ atom % total K, $\lambda e = 5.85 \times 10^{-11}$/yr, $\lambda\beta = 4.72 \times 10^{-10}$/yr.) The genesis of this magmatism is thought to be connected with tensional stresses and anatectic melting in the deeper crust.

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H. N. A. Priem, N. A. I. M. Boelrijk, E. H. Hebeda, E. A. Th. Verdurmen, R. H. Verschure and E. H. Bon (1971) : *Granitic complexes and associated tin mineralizations of 'Grenville' age in Rondônia, Western Brazil.* Geol. Soc. America. Bull. 82, 1095-1102.

A. J. Versteeve (*)

Progress-report on Rb-Sr investigations in the charnockitic Precambrian of Rogaland and Vest-Agder, S. W. Norway

Since 1964, the « charnockitic Precambrian » of Rogaland and Vest-Agder, S. W. Norway, has been the subject of petrological and geological investigations by a research team from the University of Utrecht (Tobi, 1965). In connection herewith, an isotope-geochronological study was started in 1969 by the present author. This paper is a progress-report of the results obtained so far.

Two major lithological units are distinguished in the « charnockitic Precambrian » : *the intrusive complex* (anorthosites, leuconorites, norites and minor amounts of monzonites, monzonorites and mangerites) and the *gneissic envelope*. The latter comprises three main rock types : charnockitic and granitic migmatites (the former granulite facies rocks containing hypersthene, the latter amphibolite facies rocks, cf. Dahlberg, 1959), augengneisses (granitic in composition with potassium feldspar megacrysts), and garnetiferous migmatites (probably derived from argillaceous sediments). Within the charnockitic and granitic migmatites, there are also masses of syenitic rocks.

The isotope-geochronological investigations (so far only Rb-Sr measurements) deal mainly with the rocks of the gneissic envelope.

Biotites from two augengneisses and one granitic migmatite produce Rb-Sr ages around 825 m. y. This date probably represents the final stage of regional cooling after the termination of the Dalslandian tectonothermal events that affected south-western Scandinavia (900-1000 m. y. ago).

A whole-rocks isochron computed through 28 data points of charnockitic and granitic migmatites corresponds with an age of 1480 $\pm$ 80 m. y. and an initial $^{87}Sr/^{86}Sr$ ratio of 0.702 $\pm$ 0.003 (errors with 95 % confidence level as calculated from the analytical data, $\lambda = 1.47 \times 10^{-11}$/yr). There is some scatter of data points about the best fitted straight line, obviously due to geological sources of variance (probably

some Rb and Sr redistributions during the Dalslandian events). An isochron through 12 data points from the northern part of the area shows an age of 1340 $\pm$ 100 m. y. with an initial ratio of 0.706 $\pm$ 0.003, whereas an isochron through the remaining 16 data points in the southern part gives an age of 1530 $\pm$ 100 m. y. with an initial ratio of 0.700 $\pm$ 0.003. This may be interpreted as suggesting a stronger imprint of the Dalslandian events towards the North.

From the syenitic masses only five whole-rock samples have been measured so far. All data points are situated below the 1480 m. y. isochron, suggesting either an age younger than that of the surrounding migmatites, or a stronger imprint of the Dalslandian events.

As a reconnaissance, four whole-rock measurements were made on mangeritic rocks from the intrusive complex. The preliminary data do not completely rule out the possibility that these rocks are older than indicated by the zircon ages obtained by PASTEELS and MICHOT (1968, 1969).

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PH. VIDAL (*)

Rb-Sr AGE DETERMINATIONS ON MINERALS AND TOTAL ROCKS OF THE MOELAN AND LANVAUX GRANITES (SOUTH BRITTANY)

The till now Precambrian considered Moelan and Lanvaux massives form a granite-gneiss E. W. axis, involved and sheared in the Hercynian orogen. The geochronological Study, by the Rb-Sr whole-rock isochron method, shows in fact the existence of three episodes of plutonism, from Cambrian to Silurian : 534 $\pm$ 8 m. y. $(^{87}Sr/^{86}Sr)_i$ = 0,7031) in both massives, 457 $\pm$ 2 m. y. $(^{87}Sr/^{86}Sr)_i = 0.7030$) in the Moelan massif, 456 $\pm$ 8 m. y. $(^{87}Sr/^{86}Sr)_i$ = 0,7041) and 418 + 4 m. y. $(^{87}Sr/^{86}Sr)_i$ = 0.7061) in the Lanvaux massif ($\lambda\ ^{87}Rb = 1.47\ 10^{-11}\ y^{-1}$).

Rb — Sr minerals isochron from the Moelan granite, gives an age at 283 $\pm$ 12 m. y. $(^{87}Sr/^{86}Sr)_i = 0.7214$); this event, general in the diverses formations of the South of the Armorican Massif, likely corresponds to the cooling phase, in the late stage of the Hercynian orogenesis.

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A. Vitrac (*)

Anatexis origin of a charnockitic granite proved by geochronology : ^{87}Rb-^{87}Sr and U-Th-Pb systematics in Agly charnockites formation Pyrénées (France)

The ^{87}Rb-^{86}Sr total rocks isochron of charnockite gives an age of 580 m. y. The mineral isochron indicates an isotopic disturbance at about 60 or 50 m. y.

A granitic charnockite yields by Rb-Sr a Hercynian 300 m. y. age.
This granite was studied by U-Th-Pb on zircons and monazite.

The monazite and some zircons gives 300 m. y. while a zircon yields a very discordant age and the Concordia plot indicates a very old age.

The results prove that the granite is an anatectic granite made at the expense of a charnockitic paragneiss.

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G. A. Wagner and G. M. Reimer (*)

Fission-track dating of apatites from the Central Alps.

Apatite concentrates from about 50 localities along a North-South profile through the Aare-massif, Gotthard-massif, Pennine nappes (Simplon area) and the Southern Alps were dated with the fission track method. The measured fission-track ages range between 2 m. y. and 15 m. y. These ages are younger than the corresponding Rb/Sr mica ages on the same samples previously dated by Jäger et al. Generally, these younger ages can be explained as cooling ages to 125 $\pm$ 15°C.

The age pattern shows a regional and an altitude dependence and thus appears to be related to the uplift history of this Alpine region.

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G. A. Wagner (*) and D. Storzer (**)

Fission track shortening as an indicator of the thermal history of apatites

Fission tracks in apatites may be successfully used for resolving the thermal history of rocks in the low temperature range (below 200°C). In annealing experiments with apatites it was established that the etching rate along fission tracks decreases with increasing thermal influence, e. g. the tracks become shorter for a given etching time. The lengths of fission track etch channels were measured in apatites from the crystalline basement of the Odenwald (Germany). The fossil tracks show a two-peaked length-distribution compared to the one-peaked length distribution of the induced tracks, indicating a complex thermal history of these apatites. The results agree well with the known geological history of this area : Permian uplift, early Mesozoic sinking, and late Mesozoic and Cenozoic uplift.

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I. WENDT, C. BESANG, W. HARRE, P. MÜLLER, H. KREUZER, H. LENZ (*)

RADIOMETRIC AGE DETERMINATIONS IN THE PRECAMBRIAN OF TANZANIA

An area between 7^0 and $9{,}5^0$ S and $34{,}5^0$ to 36^0 E has been mapped by a German Geological mission. The northern part belongs to the old Dodoman formation which consists mainly of gneisses intruded by granites. The younger Usagaran formation in the South which also has been intruded by granites is separated from the Dodoman byt he Konse series. The Dodoman gneisse syielded Rb/Sr total rock ages of 2500 m.y., while the granites in the Dodoman region fit on a 1850 m. y. total rock isochron. This date could be reconfirmed by Rb/Sr and K/Ar mica-dates while the mica dates of the older gneisses yield the same age.

Rb/Sr total rock ages of all the granites and vulcanites in the Usagaran formation are close to 1850 my, but the mineral ages show a strongly decreasing tendency from NW to SE. They are as low as $\sim$ 300 my in the South-East and Rb/Sr and K/Ar mineral ages are highly discordant indicating an influence with an increasing intensity towards South East.

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