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APATITE FISSION TRACK DATING OF PRECAMBRIAN INTRUSIVE ROCKS FROM THE SOUTHERN ROGALAND (SOUTH-WESTERN NORWAY)

by P. VAN DEN HAUTE (*)

ABSTRACT. - The Rogaland anorthositic complex, intruded during the Sveco-Norwegian tectonic phase in Southern Norway, has been the object of intensive radiometric dating.In this study some age measurements, based upon the fission track method applied to apatite minerals, are presented. The obtained ages range from 222 to 258 m.yr. and the mean age lies at 241 m.yr. (Zechstein). This result cannot be correlated with the late Precambrian ages of formation or subsequent postorogenic uplift, obtained with other methods. The Upper-Permian age is interpreted as the result of a complete annealing of the preexisting tracks mainly due to the burial of the massif under Cambro-Silurian sediments during the Caledonian Cycle. The complete erosional removal of these sediments occured only in Upper-Permian times or later as a result of renewed uplift. The fission track ages are then considered to reflect the cooling of the area during this uplift.

SAMENVATTING. - Het anorthosietisch complex van zuidelijk Rogaland, geïntrudeerd tijdens de Sveco-Norwegische plooiïngsfase is reeds het voorwerp geweest van intensieve radiometrische datering. In deze studie werden de eerste dateringen uitgevoerd met de fission track methode toegepast op apatiet. De bekomen ouderdommen variëren tussen 222 en 258. 10^6 jaar en de gemiddelde ouderdom bedraagt 241.10^6 jaar (Zechstein). Dit is volledig afwijkend van de Precambrische ouderdommen, die bekomen werden met andere methodes en die terugslaan op de vorming of op de hieropvolgende postorogenetische opheffing van het complex. De Boven-Perm-ouderdom werd geïnterpreteerd als zijnde het gevolg van een vrijwel volledige thermische uitwissing van alle vroeger gevormde tracks. Een begraving onder Cambro-Silurische sedimenten tijdens de Caledonische cyclus is waarschijnlijk de belangrijkste oorzaak van deze uitwissing. De volledige erosie van deze sedimenten gebeurde slechts in het Boven-Perm of later als gevolg van een hernieuwde opheffing. De bekomen ouderdommen werden verondersteld overeen te komen met de tijd waarin de fission track opnieuw stabiel zijn geworden als gevolg van de afkoeling, die met deze opheffing gepaard ging.

RESUME. - Le complexe anorthositique du Rogaland méridional, mis en place pendant le cycle tectonique svéco-norwégien a déjà fait l'object de nombreuses datations radiométriques. Dans cette étude sont présentées les premières datations effectuées par la méthode des traces de fission appliquée sur apatite. Les âges obtenus varient entre 222 et 258 m.a., l'âge moyen se situant à 241 m.a. (Zechstein). Ce résultat ne montre aucun rapport avec les âges précambriens, correspondant à la formation ou à la montée postorogénique du complexe, qui sont obtenus par d'autres méthodes. On en conclut qu' une disparition thermique presque totale des traces de fission antérieures au Permien supérieur s'est produite par suite de l'enfouissement du massif sous une couverture sédimentaire cambro-silurienne pendant le cycle calédonien. L'enlèvement de ces sédiments ne s'est produit que pendant le Permien supérieur ou même ultérieurement lors d'une nouvelle phase de soulèvement. Les âges des apatites sont ainsi interprétés comme les âges du refroidissement du massif accompagnant ce soulèvement.

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INTRODUCTION.

Since it has been introduced by PRICE and WALKER in 1963, the fission track dating method has become an important tool in geochronology, the whole dating technique being now only one facet of the rapidly expanding field of solid state nuclear track detection.

At the present time a wide range of minerals and glasses have been investigated by this method. Artificial glasses less than 40 years old have been dated with precision (BRILL, 1966) while at the other side of the time scale, NAESER and FAUL (1969), have recorded a fission track age of 1300 m.y. concordant with a Rb-Sr whole rock age determination.

However for ages greater than 200 m.y., fission track results are frequently discordant with dates obtained by other radiometric methods, the fission track dates being systematically lower. Thermal fading of the tracks has been pointed out to be the main factor responsible for the lowered ages (FLEISCHER, PRICE and WALKER, 1965).

Considering the Fennoscandian shield two important fission tracks studies may be mentioned, WELIN et al. (1972) recorded fission track ages ranging between 230 and 1255 m.y. on hornblende, biotite and phlogopite cleavage planes. The authors stated that the minerals had suffered both from thermal fading of the tracks and from recent uranium migration. Therefore a precise geological interpretation of the obtained ages was impossible.

LEHTOVAARA (1976) measured fission track ages on apatites of different synorogenic intrusives from the Svecokarelides (1800-1900 m.y.) in Finland. He interpreted the fission track results ranging from 520 to 980 m.y. as manifestations of slow cooling and differential land uplift in the Precambrian basement.

Finally HAACK (1975) has reported some fission track age measurements of the Norwegian basement (Arendal region) on garnet and vesuvianite yielding 924 ± 62 m.y. and 761 ± 53 m.y. respectively and probably also reflecting the slow cooling history of this area.

In the present study fission track dating has been applied to apatites of different intrusives from the Southern Rogaland igneous complex. Apatite, known for its high sensitivity for thermal track fading, is prominently used for dating the last stages of the cooling history of a rock body. The Precambrian anorthositic complex of Southern Rogaland is geologically and petrologically well investigated. It has been dated by conventional radiometric methods and is therefore an interesting object for apatite fission track dating.

THE FISSION TRACK DATING METHOD.

The fission track dating method has already been treated extensively in several publications. A recent review has been given in WAGNER (1972) and FLEISCHER et al.(1975).

Therefore only the principles of the method will be outlined here. The fission track method is based on the spontaneous fission of ^{238}U, present as a trace element in minerals (or glasses). The two fission fragments produced by this process are expelled in opposite directions creating a narrow cylinder of radiation damage in the crystal lattice. This damaged zone, or fission track, is 10-20µ long and some tens of Ångstroms wide. Chemical etching widens the tracks so that they become visible under an optical microscope.

As time proceedes fission tracks will accumulate in the mineral and the track density ρ_s or number of tracks counted on a unit area of a polished and etched surface, will be a function of the age and uranium concentration of the material.

This allows to calculate the age T from the following equation :

$$T = \frac{1}{\lambda_d} \ln \left(\frac{\rho_s}{2\, \lambda_{f}/\lambda_d \cdot N_v . C_U . R} + 1 \right) \qquad (1)$$

where :

λ_d = decay constant for α-decay of ^{238}U (= $1.54.10^{-10}$ yr^{-1})

λ_f = decay constant for spontaneous fission of ^{238}U

N_v = atomic density of the mineral

C_U = atomic concentration of ^{238}U

R = mean length over which a fission track is revealed by etching.

The factor 2 occurs when the tracks are counted on an internal surface of the minerals (4π-geometry). There is still no general agreement about the exact value of λ_f. Two values $6.85.10^{-17} yr.^{-1}$ (FLEISCHER and PRICE, 1964) and $8.42.10^{-17}.yr.^{-1}$ (SPADAVECCHIA and HAHN, 1967) are in use and the arguments that would corroborate definitely one of these two constants have not been provided yet.

To determine the ^{238}U concentration in the mineral, the sample is send to a nuclear reactor where it is exposed to a well determined fluence of thermal neutrons. This neutron irradiation induces a fission reaction of ^{235}U in the mineral. From the density ρ_i of induced tracks the ^{238}U concentration can be calculated with the following equation :

$$C_U = \frac{\rho_i}{2.I.N_v.\emptyset.\sigma.R} \qquad (2)$$

where :

I = the isotopic ratio $^{235}U/^{238}U$ (= $7.26.10^{-3}$)

$\emptyset$ = thermal neutron dose

σ = fission cross section of ^{235}U for thermal neutrons (= 582.10^{-24} cm^2)

Substitution of eq. (2) in eq. (1) yields the final age equation.

$$T = \frac{1}{\lambda_d} \ln \left(\frac{\lambda_d}{\lambda_f} \cdot \frac{\rho_s}{\rho_i} \cdot I.\emptyset.\sigma + 1\right) \qquad (3)$$

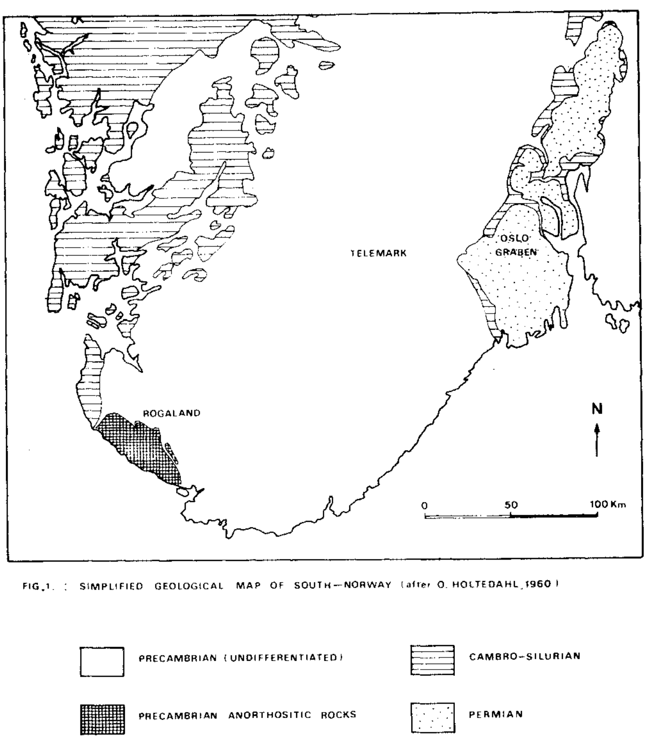

FIG.1. : SIMPLIFIED GEOLOGICAL MAP OF SOUTH-NORWAY (after O. HOLTEDAHL, 1960)

From this equation it can be seen that an accurate determination of the ρ_s/ρ_i ratio is the main task in fission track dating. In practice there are several methods for determining this ratio, depending upon the kind of material and the degree of homogeneity of the uranium distributed in it.

GEOLOGICAL SETTING.

The Rogaland anorthositic complex is considered to have intruded during the orogenic stage of the Sveco-Norwegian cycle. The complex comprises five main intrusive units (J. and P. MICHOT, 1969) (fig. 2) :

(1) the Egersund-Ogna massif, a hololeucocratic anorthosite body with a gneissic border richer in ferromagnesians.

(2) the Lakssvelefjeld-Koldal intrusion of noritic composition forming a narrow border around the Egersund-Ogna massif. The magmatised norito-granitic southern part of the intrusion contains several Fe-Ti ore bodies.

(3) the Bjerkrem-Sogndal massif, a layered lopolith resulting from gravity differentiation of a plagioclasic magma. In this lopolith three main phases have been distinguished :

- a leuconoritic phase consisting of five rhytmic units
- a monzonoritic phase surmounting the former in perfect conformity. The quartz-monzonoritic intrusion of Eia-Reckefjord emplaced between the southern part of the Bjerkrem-Sogndal massif and the Håland-Helleren massif has formerly been considered as a part of this phase (MICHOT, 1960) but RE-data show that this intrusion cannot be regarded as a member of the Bjerkrem-Sogndal differenciation suite (DUCHESNE et al. 1974).
- a mangeritic phase constituting the upper part of the lopolith.

(4) the Håland-Helleren massif and (5) the Åna-Sira massif composed of anatectic leuconorite and paranatectic **anorthosite.** Both massifs contain Fe-Ti ore bodies

The emplacement of the various massifs occured during the Sveco-Norwegian orogeny which has been divided in three major tectonic phases (MICHOT, 1960).

The Egersund-Ogna massif and the Lakssvelefjeld-Koldal intrusion were emplaced during the first phase. The Bjerkrem-Sogndal massif intruded during the second phase although crystallization continued down to the third phase. The Håland -Helleren massif was emplaced some time between the formation of the two former massifs.

Subsequently the igneous complex has been subjected to strong postorogenic uplift which may already have started in the third tectonic phase. Paleomagnetic investigations revealed similar magnetisation directions of the anorthosite bodies, the lopolith and the metamorphic envelope, indicating a simultaneous cooling of the various parts in the Rogaland basement during uplift (POORTER, 1972). When the Rogaland complex reached epizonal conditions important faulting activity took place. Along the faults not only vertical but in some cases also considerable horizontal movements occured (MICHOT, 1960)

The last uplift stages are characterised by the intrusion of dolerite and trachydolerite dikes, trending WNW-ESE. The chilled and glassy margins of these dikes are indicative for the low depth level of intrusion which was less than 4000 m according to the crystallization experiments of CHRISTIE (1959).

Finally the Rogaland complex reached the surface, as a part of the South-Norwegian Precambrian massifs which were gradually eroded to a large peneplain, achieved in sub-Cambrian times (BARTH & REITAN, 1963).

About the influence of the Caledonian cycle upon the Rogaland basement only little is known. STORMER (1967) suggests that the South-Norwegian area was the domain of a foreland sedimentation during the geosynclinal stage. Although, due to the lack of Cambro-Silurian sediments, the South-Norwegian basement has been considered as an emergent block on most paleogeographic maps of the early Paleozoic (STORMER, 1967; ZIEGLER, 1975). The effect of the Caledonian orogeny itself was restricted to a rather slight, large-scale deformation of the basement rocks in the South-Norwegian area.

Later movements may have occured during Permian times in connection with the formation of the Oslo graben and more directly with the South-Norwegian boundary fault along which the first movements may have started in the late Carboniferous-early Permian (WHITEMAN et al., 1975).

Finally the large scale Cenozoic uplift of the Scandinavian landmass (HOLTEDAHL, 1960) must in some way also have affected the Rogaland basement.

GEOCHRONOLOGY.

Only the intermediate and acid members of the Rogaland igneous complex could be dated radiometrically. Dating occured mainly with Rb-Sr and U-Pb methods.

According to VERSTEEVE (1974) the emplacement of the Bjerkrem-Sogndal lopolith took place at about 950 m.y. while the final solidification of its quartz-monzonitic phase may have occured as late as 860 m.y.

In the metamorphic envelope the maximum metamorphic activity has been dated 1000 m.y. (PASTEELS & MICHOT, 1975), this age can also be accepted for the emplacement of the Egersund-Ogna anorthosite body.

K-Ar measurements on biotites of the metamorphic envelope yielded ages around 860 m.y. reflecting the postorogenic cooling and uplift of the Rogaland area(VERSTEEVE, 1974).

Regarding the intrusion conditions values of 6-7 kb (22-25 km) and 730°-750° C seem acceptable for the Egersund-Ogna massif (DE WAARD et al., 1974), indicating an average geothermal gradient of 29°-34°C/km. Accepting a closure temperature of 300°C for K-Ar in biotite and a constant geothermal gradient, the Rogaland complex reached a depth level of 9-10km at around 860 m.y. From the former data an uplift of approximately 14 km in 140 m.y. can be deduced corresponding to an average uplift rate of 0.10 mm/yr.

Only one age measurement has been carried out on the dolerite dikes yielding 633 m.y. This result, obtained by VERSTEEVE with the K-Ar method, probably reflects argon leakage and can therefore not be accepted as the age of intrusion.

Taking into account the results of CHRISTIE (1959) and assuming a constant uplift rate, a speculative maximum age of approximately 800 m.y. can be infered for the intrusion of the dike system. This age seems consistent with the paleomagnetic results of POORTER (1972).

INVESTIGATED SAMPLES.

Five apatite samples separated from different rock types of the Rogaland complex have been provided by J.-C. DUCHESNE * for fission track dating. Specifications considering provenance and rock type are listed in table 1. The localisation of the samples is indicated on fig. 2.

Table 1 : list of investigated samples

Sample N°	Geological unit	Locality	Rock type	References
1)7969	Bjerkrem-Sogndal lopolith phase 1, rhytm III	Klungland-Helleland road	Norite	Roelandts & Duchesne, 1978
2)66-212	Bjerkrem-Sogndal lopolith phase 1, rhytm IV	Bakka	Pyroxenite	Duchesne, 1972 Roelandts & Duchesne, 1978
3)66-125	Eia-Rekefjord intrusion	Rekefjord	Quartz-monzonorite	Duchesne et al. 1975
4)66-181	Lakssvelefjeld-Koldal intrusion	Kydlandsvatn	Fe-Ti ore	Duchesne, 1973 Roelandts & Duchesne, 1978
5)66-33	Håland-Helleren massif	Hesnes	Fe-Ti ore (Nelsonite)	Duchesne, 1973 Roelandts & Duchesne, 1978

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EXPERIMENTAL PROCEDURE.

The investigated samples consisted of pure apatite grains with a average grain size of 150µ. According to the procedure described by NAESER (1967) each sample has been divided in two portions. The first portion was held apart for fossil track counting. The second part was heated at 450°C for 24 hours to anneal all fossil tracks and subsequently send to the nuclear reactor for irradiation.

Then each portion was mounted in Araldite and ground to obtain an internal surface of the grains, needed for 4π-geometry counting. The mounts were polished with 3µ and 1µ diamond paste and etched in 2.5% HNO_3 for 50 seconds at 22°C. This etching with strongly diluted HNO_3 ensures an equal attack of the grains regardless of the crystallographic orientation of the etched crystal face (WAGNER & REIMER, 1972). The mounts with irradiated grains and natural grains of the same sample were etched together.

Irradiation occured in channel 8 of the Thetis reactor (Institute for Nuclear Sciences, University of Gent). In this channel the thermal neutron flux is 2.10^{11} n. $cm.^{-2}.sec^{-1}$ with a $\emptyset_{epi}/\emptyset_{th}$ ratio of 1/190 (where $\emptyset_{epi}$ = epithermal neutron flux per logaritmic energy interval).

The samples were irradiated for 7 hours. The neutron fluence was determined from a SRM-612 glass of the National Bureau of Standards, incorporated with the samples during irradiation. The value of the fluence was obtained by comparing the track density in this glass with that of three similar glasses exposed to different neutron fluences and calibrated with Au and Co monitors. The tracks were counted by one person, using the oil (n = 1.515) immersion technique (WAGNER, 1968).

Of each sample two mounts for natural and for induced tracks have been prepared yielding two age determinations per sample.

AGE CALCULATION AND ERROR.

The ages have been calculated using eq. (3) and the value $8.42.10^{-17}.yr^{-1}$ for λ_f, adopted by most European authors (*). The results are listed in table 3.

The error on the fission track age measurements depends greatly upon the precision with which ρ_i, ρ_s and $\emptyset$ are determined.

In practice, using the microscope grid as unit area, a number of unit areas counted and the mean track density $\bar{\rho}$ per unit area is calculated. The error $S\bar{\rho}$ of the mean is evaluated from $S\bar{\rho} = \frac{S}{\sqrt{n}}$ (where S = standard deviation and n = number of unit areas) and the relative error from $\frac{S\bar{\rho}}{\bar{\rho}} = \frac{C}{\sqrt{n}}$ (where $C = \frac{S}{\bar{\rho}}$ = coefficient of variation).

The relative error of the age is then calculated with the following equation (HAACK, 1976).

$$\frac{\Delta T}{T} = \sqrt{\left(\frac{C}{\sqrt{n}}\right)_s^2 + \left(\frac{C}{\sqrt{n}}\right)_i^2 + \left(\frac{\Delta\emptyset}{\emptyset}\right)^2}$$

The mode of distribution of uranium in the mineral affects greatly the standard deviation and therefore also the variation coefficient C. Hence C has been used to evaluate the degree of homogeneity of uranium in the minerals (HAACK, 1973, 1976). However a homogeneous U-distribution does not stand for a low C-value. In fact a perfectly homogeneous U-distribution should yield a Poisson-distribution of the tracks which means that C is a function of the mean track density $\left(C = \frac{1}{\sqrt{\bar{\rho}}}\right)$ and a homogeneous U-distributions whith low track densities will also yield a high value of C.

In our opinion a goodness-of-fit test to the Poisson distribution is more appropriate to evaluate the degree of homogeneity of uranium in the minerals. If this test is affirmative the error of the mean track density will approximate $\frac{1}{\sqrt{n\bar{\rho}}}$, from which the number of tracks to be counted, in order to keep the error beneath a presumed limit, can be estimated.

The fission track distribution of the Rogaland apatites have been investigated with a goodness-of-fit test to the Poisson distribution. All samples showed a fair homogeneity of uranium except for sample 66-212 which was slightly heterogeneous (at the 95% confidence level).

(*) Recently also the values $8.46.10^{-17}$ and $8.5.10^{-17}yr^{-1}$ have been used. The use of one of these values, instead of the one adopted here, would have had a negligeable effect on the final ages.

Table 2 : Fission track densities and errors

Sample n°	Spontaneous tracks						Induced tracks					
	n° of tracks	$\bar{\rho}_s$/u.a.	C_s	(✱) C_p	error of $\bar{\rho}_s$ in %	tracks/ $cm^2 (x10^5)$	n° of tracks	$\bar{\rho}_i$/u.a.	C_i	C_p	error of $\bar{\rho}_i$ in %	tracks/ $cm^2 (x10^5)$
1) 7969-a	973	9.73	0.28	0.32	2.8	0.675	983	9.83	0.29	0.32	2.9	0.682
7969-b	884	8.84	0.31	0.34	3.1	0.613	921	9.21	0.35	0.33	3.5	0.639
2) 66-212-a	1497	32.6	0.25	0.18	3.7	2.26	1350	32.6	0.25	0.18	3.9	2.26
66-212-b	1050	33.1	0.27	0.17	4.8	2.30	1123	32.8	0.26	0.18	4.4	2.28
3) 66-125-a	2438	51.2	0.16	0.14	2.3	3.55	2442	50.4	0.15	0.14	2.2	3.50
66-125-b	2444	51.1	0.14	0.14	2.0	3.55	2375	48.1	0.15	0.14	2.1	3.34
4) 66-181-a	481	8.52	0.29	0.34	4.3	0.591	187	8.61	0.34	0.34	7.3	0.597
66-181-b	323	9.28	0.27	0.33	4.6	0.644	508	10.20	0.27	0.31	3.8	0.707
5) 66-33-a	3014	67.0	0.17	0.12	2.5	4.65	2922	64.3	0.15	0.12	2.2	4.47
66-33-b	3373	69.4	0.16	0.12	2.3	4.82	3586	73.6	0.14	0.12	2.20	5.10

(✱) C_p = coefficient of variation of the corresponding Poisson distribution

The values of $\bar{\rho}$, C and $S\bar{\rho}$ are listed in table 2. From this table it can clearly be seen how C diminuishes with rising values of the mean track density $\bar{\rho}$.

Also the uranium content of the apatite samples has been calculated (table 3). For this purpose one needs to determine the value of R in eq. (2).

This is normally done by track counting on an apatite sample with known U-content which was prepared in the same way as the other samples. Subsequently the value of R calculated from eq. (2) can be used to determine the U-content of the other samples using the same equation.

Unfortunately there were no apatites with known U-content available from the Rogaland complex. Therefore we adopted the value R = 2.04μ determined by WAGNER (1968) on apatite from Durango (Mexico). In this case the U-content in ppm is given by

$$C_U \text{ (ppm)} = 7.4.10^{10}\rho_i/\emptyset$$

As the etching conditions of the Mexican apatite were different from those used in the present study, the presented U-contents of the Rogaland apatites can only be regarded as rough estimations.

Table 3 : Fission track ages (*) and Uranium content

Sample No	age in m.y.	C_U in ppm
2) 66-212-a	243 ± 18	3.4
66-212-b	245 ± 20	3.4
1) 7969-a	241 ± 15	1.0
7969-b	234 ± 16	0.9
3) 66-125-a	247 ± 15	5.2
66-125-b	258 ± 15	5.0
4) 66-181-a	241 ± 24	0.9
66-181-b	222 ± 17	1.0
5) 66-33-a	253 ± 15	6.6
66-33-b	230 ± 13	7.6

(*) $\lambda f = 8.42.10^{-7} yr^{-1}$

$\emptyset = 4.98.10^{15}$ neutrons/cm^2 (± 5 %)

DISCUSSION.

The obtained ages range from 222 to 258 m.y. Regarding the differences which may occur between two age measurements on the same sample (samples 4 and 5) and taking into account that the age errors whe only calculated at the 1σ confidence level, significant differences between the various ages cannot be established. Therefore the various ages can, in our opinion, be replaced in a justified way by their mean which lies at 241 ± 17 m.yr. and falls in the Upper-Permian (Zechstein).

This age cannot be correlated with the results obtained with other radiometric methods. This may be unexpected. Indeed, from the fact that fission tracks in apatite become stable in the 100°C temperature region one normally expects an age younger than the K-Ar biotite ages of 860 m.yr. but still falling in the Precambrian as the area was peneplanised before the Cambrian. The apatite ages need therefore a special explanation.

Uranium enrichment of the apatite may be responsible for the lowering of the ages. However from the geological part of view it is highly improbable that such enrichment has occured. Also all apatites showed a homogeneous Uranium distribution and zones with abnormal track densities or track concentrations along fractures, regarded as possible indications of Uranium migration, were absent.

Thermal fading of the tracks seems therefore the only explanation for the lowered ages.

Regarding the causes or events which may have been responsible for this annealing three possibilities can theoretically be taken into account :

(1) a burial of the massif under a cover of sediments
(2) a general rise of the geothermal gradient
(3) heating of the rocks induced by magmatic activity.

As the late Precambrian dolerite dikes were the latest sign of magmatic activity in the Rogaland area, the third possibility may be excluded as a cause for track annealing.

A rise of the geothermal gradient cannot be excluded a priori, although it cannot have been solely responsible for the track fading as the samples come from a late Precambrian surface. A burial under a sedimentary cover must therefore necessarily be inferred to explain, at least partially, the resetting of the fission track clock in the apatites.

Regarding the time during which the annealing event or events occured there are also three possibilities :

(1) the annealing occured between the time of peneplanation and the time indicated by the fission track ages. In this case the annealing of all pre-Upper-Permian tracks was complete. The fission track ages are then cooling ages corresponding with the time when the temperature was sufficiently lowered to permit a definite stabilization of the tracks.
(2) track annealing occured later than the time indicated by the fission track ages.In this cas the annealing must have been partial in order to produce the Upper-Permian ages which therefore are mixed ages.
(3) annealing events occured as well before as after the time indicated by the fission track ages. Also here the events must have caused a partial annealing and the apatite ages are mixed ages.

As we already know that a sedimentary cover is one of the annealing causes the second possibility may here be excluded whereas, in the area under investigation, there were no marine transgressions since Paleozoic times.

Although no systematic track length analysis has been carried out, the length distributions of induced and spontaneous tracks did no seem to differ largely. Therefore also the third possibility can be rejected since in the case of several partial annealing events the length distribution of spontaneous tracks should show a distinct enrichment in shorter tracks.

The former deductions lead to a sedimentary cover of post-late Precambrian to pre-Upper-Permian age as the main cause for the track annealing and considering the regional geology of the area, a Cambro-Silurian cover deposited during the Caledonian cycle seems the must plausible.

Herewith it is not improbable that the supply of the overlying rocks, not only occured by sedimentation but also in a tectonic way during the Caledonian orogeny.

The principal events which might have been responsible for an eventual rise of the geothermal gradient are the Caledonian orogeny and the Permian period of crustal instability and magmatism in Southern Norway (Oslograben). However, in our opinion, the thermal effect of these events on the Rogaland region was probably only of minor importance.

From laboratory experiments (NAESER and FAUL, 1969; WAGNER and REIMER, 1972) and from recent fission track studies of borehole samples (NAESER and FORBES, 1976) a temperature of ~ 100°C may be regarded as sufficient to errase pratically all the tracks in apatite minerals, in the case of a long-term annealing (~100 m.yr.). The fact that the tracks only became stable in the Upper-Permian speaks for such a long-term annealing. So, assuming a normal geothermal gradient of 30°C/km during the annealing period, a minimum thickness of 3-4 km can be tentatively infered for the overlying sediments.

The fission track ages probably reflect a renewed uplift of the basement.Features like the South Norwegian bassin where up to 1200 m of Triassic sediments have been deposited (PEGRUM et al., 1975) may be related to this uplift.

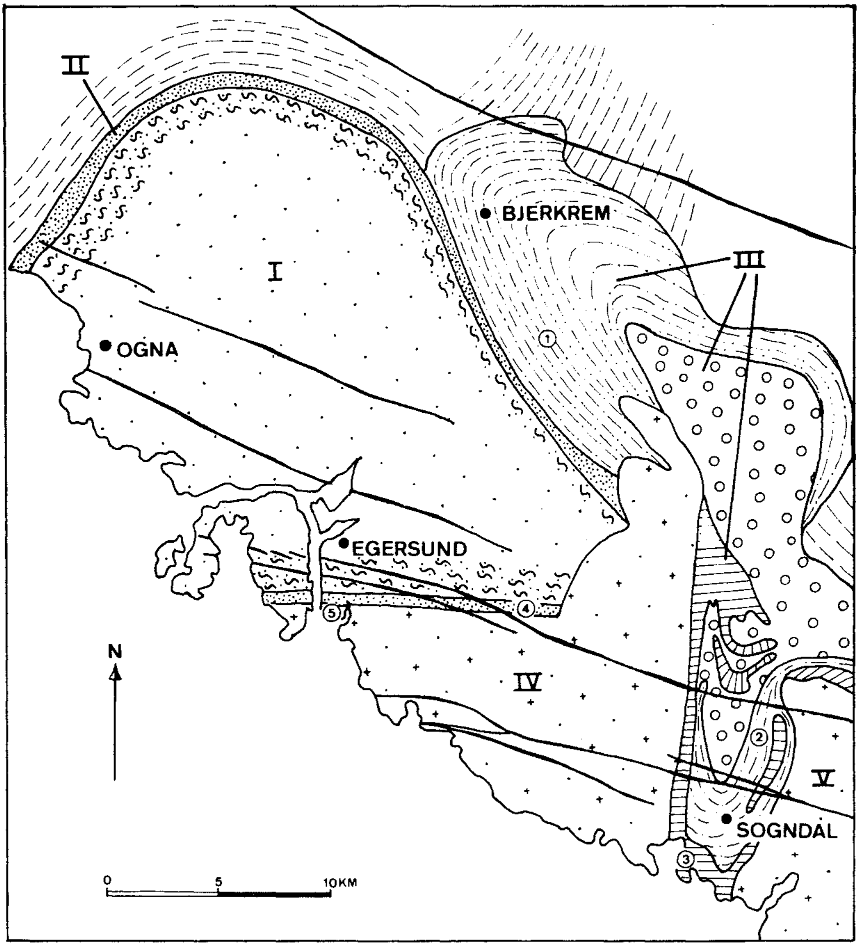

FIG. 2 THE IGNEOUS COMPLEX OF SOUTHERN ROGALAND (after P. MICHOT, 1960 and J. & P. MICHOT, 1969)

EGERSUND-OGNA MASSIF (I)

- ANORTHOSITE
- ANORTHOSITIC AND LEUCONORITIC GNEISS

LAKSSVELEFJELD-KOLDAL INSTRUSION (II)

- MIGMATITIC NORITE

BJERKREM-SOGNDAL MASSIF (III)

- LEUCONORITIC PHASE
- QUARTZ-MONZONORITE (EIA-REKEFJORD INTRUSION)
- MANGERITIC PHASE

HÅLAND-HELLEREN- (IV) AND ÅNA-SIRA (V) - MASSIF

- ANATECTIC LEUCONORITE AND PARANATECTIC ANORTHOSITE
- SURROUNDING GNEISSES
- DOLERITE AND TRACHYDOLERITE DIKES
- ① SAMPLING POINTS

However, it is impossible to reconstruct the uplift history of the Rogaland basement solely based on the apatite ages. The only fact can be infered is that a considerable volume of overlying rocks must have been eroded in Upper Permian times or later in order to reexpose the basement massifs. This seems consistent with the observations made in the Oslo graben (HOLTEDAHL, 1960) where up to 1400 m of Cambro-Silurian sediments have been preserved from erosion by the Permian downfaulting.

ACKNOWLEDGMENTS.

This study forms a part of a project supported by the IWONL/IRSIA. We are grateful to Prof. Dr. R. MARECHAL who accepted to be the promotor of this project. Dr. P. DE PAEPE and Dr. J. KLERKX are gratefully acknowledged for critically reading the manuscript and for their help and advice. We are also indebted to Dr. J.-C. DUCHESNE for providing the apatite samples and for the ample information he kindly put at our disposal.

REFERENCES

BARTH, T.F.W. and REITAN, P.H. (1963) - The Precambrian of Norway in : Kalervo Rankama ed., The Precambrian Vol. 1, pp 27-80, John Wiley & Sons, London.

BRILL, R.H. (1966) - Applications of fission-track dating to historic and prehistoric glasses. Archaeometry, 9, pp 51-57.

CHRISTIE, O.H.J. (1959) - Crystallization experiments with alkali olivine basaltic glass from Egersund. Norsk. Geol. Tidssk., 39, pp 271.

DE WAARD, D., DUCHESNE, J.-C. and MICHOT, J. (1974) - Anorthosites and their environment. Cent. Soc. Géol. Belg., Liège, pp 323-346.

DUCHESNE, J.-C. (1972) - Iron-Titanium oxide minerals in the Bjerkrem. Sogndal massif, South-western Norway. Journ. of Petrol., 13-1, pp 57-81

DUCHESNE, J.-C. (1973) - Les gisements d'oxydes de fer et titane dans les roches anorthositiques du Rogaland (Norwège méridionale). dans Coll. E. Raguin : les roches plutoniques dans leurs rapports avec les gîtes minéraux. pp 241-248. Masson et Cie, Paris.

DUCHESNE, J.-C., ROELANDTS, I., DEMAIFFE, O., HERTOGEN, J., GIJBELS, R. and DE WINTER J. (1974) - Rare earth data on monzonoritic rocks related to anorthosites and their bearing on the nature of the parental magma of the anorthosite series. Earth and Plan. Sc. Lett., 24, pp 325-335.

FLEISCHER, R.L. and PRICE, P.B. (1964) - Decay constant for spontaneous fission of ^{238}U. Phys. Rev., 133, pp 2975-2976 (B63-B64).

FLEISCHER, R.L., PRICE, P.B. and WALKER, R.M. (1965) - Effects of temperature pressure and ionization on the formation and stability of fission tracks in minerals and glasses. Journ. Geoph. Res., 70-6, pp 1497-1502.

FLEISCHER, R.L., PRICE, P.B. and WALKER, R.M. (1975) - Nuclear tracks in solids, principles and applications. Univ. of Calif. Press, Berkeley, 605 p.

HAACK, U. (1973) - The influence of the uranium distribution on the error of fission track ages of garnets. Abstract ECOG III, Oxford.

HAACK, U. (1975) - Aussagemögelichkeiten der Spaltspurenmethode und Spaltspuren Geochronologie des Damara-Orogens in S.W. Afrika - Habilitationsschrift, Göttingen.

HAACK, U. (1976) - Rekonstruktion der Abkühlungsgeschichte des Damara-Orogens in Südwest-Afrika mit Hilfe von Spaltspuren-Altern. Geol. Rundsch., 65-3, pp 967-1002.

HOLTEDAHL, O. (1960) - Geology of Norway - Norg. geol. Unders, nr 208, 540 p.

LEHTOVAARA, J. (1976) - Apatite fission track dating of Finnish Precambrian intrusives. Ann. ac. sc. fenn., Ser. A, III, geol. geogr., N° 117, 94 p.

MICHOT, P. (1960) - La géologie de la catazone : le problème des anorthosites, la palingenèse basique et la tectonique dans le Rogaland méridional (Norwège méridionale). Intern. Geol. Congr. Norden 21st Sess, guide A, 54 p.

MICHOT, J and MICHOT, P. (1969) - The problem of anorthosites. The South-Rogaland igneous complex, southwestern Norway, in : Origin of anorthosites and related rocks, Y.W. Isacksen ed., New-York State Mus. Sci. Serv. Mem., 18, pp 390-410.

NAESER, C.W. (1967) - The use of apatite and sphene for fission track age determinations. Bull. Geol. Soc. Am., 78, pp 1523-1526.

NAESER, C.W. and FAUL H. (1969) - Fission track annealing in apatite and sphenes. Journ. Geoph. Res., 74-2, pp 705-710.

NAESER, C.W. and FORBES, R.B. (1976) - Variation of fission track ages with depth in two deep drill holes. Trans. Am. Geophys. Union, 57, p 353

PASTEELS, P. and MICHOT, J. (1975) - Geochronological investigation of the metamorphic terrain in South-Norway. North. Geol. Tidssk., 55, pp 111-134.

PEGRUM, R.M., REES, G. and NAYLOR, D. (1975) - Geology of the North-West European continental shelf, vol. 2, 225 p., Grah. Trotman Dudley, Ltd., London.

POORTER, R.P.E. (1972) - Paleomagnetism of the Rogaland Precambrian (Southwestern Norway). Phys. Earth. Planet. Int., 5, pp 167-176

PRICE P.B. and WALKER, R.M. (1963) - Fossil tracks of charged particles in mica and the age of minerals. Journ. Geoph. Res., 68-16, pp 4847-4862.

ROELANDTS, I. and DUCHESNE, J.-C. (1978) - Rare earth elements in apatite from layered norites and Iron-Titanium ore-bodies related to anorthosites (Rogaland, S.W. Norway). Proc. 2nd Symp. on the origin and distribution of the elements, Pergamon Press (in press).

SPADAVECCHIA, A. & HAHN, B. (1967) - Die Rotationskammer und einige Anwendungen. Helv. Phys. Acta, 40, pp 1063-1079.

STORMER, L. (1967) - Some aspects of the Caledonian geosyncline and foreland west of the Baltic Shield. Quart. Journ. Geol. London, 123, pp 183-214.

VERSTEEVE, A.J. (1974) - Isotope geochronology in the high grade metamorphic Precambrian of Southwestern Norway. Doct. Thesis, Utrecht, 93 p.

WAGNER, G.A. (1968) - Fission track dating of apatites. Earth. Planet Sci. Lett., 4, pp. 411-415.

WAGNER, G.A. (1972) - Spaltspurenalter von Mineralen und natürlichen Gläsern. Fortschr. Miner., 49, pp 114-145.

WAGNER, G.A. and REIMER, G.M. (1972) - Fission track tectonics : the tectonic interpretation of fission track apatite ages. Earth. Planet. Sc. Lett. 14, pp 263-268.

WELIN, E., LUNDSTROM, I. and ABERG, G. (1972) - Fission track studies on hornblende, biotite and phlogopite form Sweden. Bull. Geol. Soc. Finland, 44, pp 35-46.

WHITEMAN, A.J., REES, G., NAYLORD, D. and PEGRUM, R.M. (1975) - North Sea throughs and plate tectonics. Norg. Geol. Unders., 316, pp 137-161.

ZIEGLER, P.A. (1975) - The geological evolution of the North Sea area in the tectonic framework of North Western Europe. Norg. Geol. Unders., 316, pp 1-27.

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INFORMATIONS

26^{me} CONGRES GEOLOGIQUE INTERNATIONAL

Le Comité d'organisation du 26ème Congrès géologique international vous prie de bien vouloir noter que celui-ci se tiendra en France, à Paris, du 7 au 17 juillet 1980, et il vous y invite cordialement.

Les excursions A, pré-congrès, se dérouleront du 27 juin au 5 juillet 1980 et les excursions C, post-congrès, du 19 au 27 juillet 1980. Ces excursions couvriront pratiquement toute l'Europe, à l'exception des pays ayant participé à l'organisation du 23ème Congrès ou candidats à l'organisation du 27ème Congrès.

Le programme scientifique comportera :

1) La tenue de VINGT SECTIONS : Pétrographie; Minéralogie; Paléontologie; Stratigraphie; Tectonique; Géologie marine-sédimentologie-pétrographie sédimentaire; Précambrien; Quaternaire-géomorphologie; Géophysique; Géochimie; Télédétection; Géologie mathématique-informatique géologique; Métallogénie-gîtes minéraux; Energies fossiles; Hydrogéologie; Géologie de l'Ingénieur-matériaux; Risques géologiques; Planétologie; Histoire de la géologie; Education-développement. Des symposium seront organisés dans le cadre de ces sections, en liaison, notamment, avec les organisations affiliées à l'Union internationale des sciences géologiques. Les résumés des communications à ces manifestations, dont les thèmes sont précisés dans la première circulaire, seront reçus jusqu'au 1er décembre 1979.

2) La tenue de SEPT COLLOQUES : Ressources minérales; Ressources énergétiques; Géologie des marges continentales; Géologie des océans; Géologie des chaînes alpines issues de la Tethys; Géologie de l'Europe, du Précambrien aux bassins sédimentaires post-hercyniens; Géologie de la France. Les organisateurs de ces colloques susciteront les communications.

Enfin, pendant la tenue du Congrès, seront organisés :

1 - une exposition scientifique et technique,
2 - la projection de films scientifiques,
3 - des excursions B, d'une ou deux journées,
4 - un programme social et un programme pour les membres accompagnateurs.

La première circulaire sera envoyée à partir du mois d'octobre 1977, les réponses devant parvenir au Secrétariat Général du Congrès pour le 1er AVRIL 1978.

Les personnes intéressées par ce Congrès et qui n'auraient pas reçu de circulaire au 15 décembre 1977 sont priées de bien vouloir en réclamer une au

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L'OBSERVATION SPATIALE DE LA TERRE ET LA GESTION DES RESSOURCES PLANETAIRES

L'AGENCE SPATIALE EUROPEENNE et le CENTRE NATIONAL D'ETUDES SPATIALES (France) organisent à Toulouse, du 6 au 10 mars 1978, dans le cadre des Journées d'Etudes Scientifiques et Technique de Toulouse (JET) et sous l'égide de **l'Assemblée Parlementaire du Conseil de l'Europe, de la Commission des Communautés Européennes** et de **l'Association Européenne de Laboratoires de Télédétection (EARSeL)**, un colloque international sur l'Observation Spatiale de la Terre et la Gestion des Ressources Planétaires (OST).

Les résultats obtenus à l'aide des premiers satellites d'observation de la terre confirment déjà les larges perspectives d'applications des techniques de télédétection dans des domaines très variés.

De telles possibilités seront exploitées et déboucheront sur une utilisation fructueuse permanente lorsque les échanges entre gestionnaires, utilisateurs et usagers d'une part, scientifiques et techniciens d'autre part, auront permis d'accorder les préoccupations des uns avec les possibilités qu'envisagent les autres.

Ce colloque se propose, dans cet esprit, de dresser un bilan des résultats obtenus pendant les premières années d'expérimentation et de traiter, en s'appuyant sur les projets à l'étude qui déboucheront pendant la prochaine décennie, les problèmes scientifiques de base associés à ces nouvelles disciplines.

INSCRIPTION

Un droit de participation de 800 FF pour les auditeurs et de 400 FF pour les conférenciers est demandé. Cette participation financière donne droit, outre à l'accès aux salles de conférences, à la fourniture d'un jeu complet des textes remis par les auteurs de communications et aux repas de midi.

Le versement des droits doit être effectué :

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« Association des Journées d'Etudes Scientifiques et Techniques de Toulouse »

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Les chèques ou virements doivent porter expressément le nom du congressiste au profit duquel le versement est effectué.

Les langues de travail du colloque sont le Français et l'Anglais. Une interprétation simultanée de ces deux langues sera assurée. Les personnes désirant participer à cette manifestation doivent retourner le bulletin d'inscription ci-joint à :

OST - B.P. N° 4130 - 31030 TOULOUSE CEDEX
Tél. : **(61) 53.11.12** - Poste 50.12 - Télex : 510 672

PROGRAMME PRELIMINAIRE

Le programme comporte 3 sessions générales et 4 sessions spécialisées qui sont constituées par des conférences invitées, des communications brèves (10 à 15 minutes maximum) et une table ronde.

SESSIONS GENERALES

1. BILAN DES RESULTATS ACQUIS PAR L'OBSERVATION SPATIALE DE LA TERRE

(conférences invitées et communications)
Coordonnateur : M. CAZENAVE

Mise en évidence des principaux résultats obtenus par observation spatiale dans les domaines tels que :
- l'agriculture et la prévision des récoltes;
- les ressources en eau;
- la gestion des zones côtières;
- la cartographie et l'aménagement du territoire;
- les ressources minières et géothermiques.

2. PROGRAMMES EN COURS ET FUTURS

(conférences invitées)
Coordonnateur : J. PLEVIN

- Brève revue des programmes en cours et présentation des objectifs des satellites de télédétection en projet.
- Pour les programmes futurs, les conférences insistent plus particulièrement sur l'analyse des tendances en matière de développement : améliorer les systèmes expérimentaux et opérationnels en vue des missions régionales et internationales.

3. GESTION DES RESSOURCES PLANETAIRES; LES ASPECTS ECONOMIQUES

(conférences invitées et table ronde)
Coordonnateur : A. LEBEAU

- Perspective à long terme;
- Intérêt économique de la télédétection spatiale pour l'Europe;
- Intérêt économique de la télédétection spatiale pour les pays en voie de développement;
- Implications juridiques, sociologiques et politiques de la télédétection spatiale.

Table ronde

Une table ronde suivra les exposés présentés à cette session.

- Les sujets débattus au cours de la table ronde seront choisis en fonction des questions qui auront été posées, avant le colloque, par les participants.

SESSIONS SPECIALISEES

A) RECONNAISSANCE DES FORMES

(conférences invitées et communications)
Coordonnateur : M. LAUDET

- Aspects généraux de reconnaissance de formes appliqués au traitement de vues spatiales (exposé introductif);
- Résultats significatifs dans le domaine de la gestion des ressources planétaires;
- Difficulté de la mise en œuvre des algorithmes classiques de reconnaissance des formes dans le domaine particulier du traitement des vues spatiales; évolution des méthodes actuellement utilisées compte tenu des progrès technologiques prévisibles (exposé de synthèse).

B) FONDEMENTS PHYSIQUES DE LA TELEDETECTION

(conférences invitées et communications)
Coordonnateur : Y. GERVAIS de LAFOND

- Paramètres mesurables à distance;
- Perturbations du rayonnement électromagnétique;
- Relations entre paramètres physiques mesurables et propriétés de la surface et de la sub-surface;
- Intéractions rayonnement électromagnétique et milieu naturel (analyes, modélisations).

C) TECHNIQUES DES HYPERFREQUENCES

(Aspects thématiques et technologiques)
(conférences invitées et communications)
Coordonnateur : M. PELEGRIN

Thèmes

- Radiomètres passifs (1-100 GHz), scatteromètres;
- Techniques du radar à ouverture synthétique;
- Balayage en fréquence ou appareils multicanaux;
- Signification des signaux reçus, interprétation des signatures passives et actives;
- Prétraitement du signal à bord;
- Possibilités d'utilisation des réponses impulsionnelles.

Technologies

- Etat de l'art des transistors FET, des mélangeurs, amplificateurs paramétriques;
- Antennes à réflecteurs et antennes plaquées; possibilités d'utiliser des antennes synthétiques;
- Choix des paramètres suivant la mission, bilans de masse et de puissance.

D) TECHNIQUES DE DETECTION POUR LE VISIBLE ET L'INFRAROUGE (conférences invitées et communications)

Coordonnateur : J. BRETON

Thèmes

- Imagerie dans le visible et l'infrarouge;
- Intérêt des diverses longueurs d'onde d'observation;
- Prétraitement du signal à bord;
- Conditions d'observation (heure locale, répétitivité);
- Stéréoscopie;
- Altimétrie, bathymétrie.

Technologies

- Progrès récents dans la technologie des détecteurs (dispositifs à transfert de charge, détecteurs pour l'infrarouge moyen et l'infrarouge thermique);
- Systèmes de refroidissement;
- Composants optiques.

CORRECTIONS A LA LISTE GENERALE DES MEMBRES PARUE DANS LE TOME 85 - FASC. 3/4 - 1976

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† JONES, Owen, T. (1958)
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GHYSENS, André-Gisbert (1973)
O.S.B. - Conservateur des collections scientifiques du Centre Grégoire Fournier, a.s.b.l., 11, rue de Maredsous, 5642-Denée.

HENRIET, Jean-Pierre (1966)
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MARECHAL, Robert (1946)
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*
* *

ERRATUM

Bull. Soc. belge Géologie, T. 85, fasc. 3-4, 1976, p. 155
Bull. Belg. Ver. Geologie, V. 85, delen 3-4, 1976, blz. 155

Due to a printer's error, the title appeared incorrectly.
It should read :

Cadulus [Gadila] dingdenensis SP. NOV. AND *Cadulus [Gadila] benoisti houthalenensis* SUBSP. NOV. FROM THE NEOGENE OF THE NORTH SEA BASIN

*
* *

REMOTE SENSING

MEETINGS - 1978

We are informed(*) of the following meetings, the list is certainly uncomplete and we will be happy to mention in the next issue those which will be communicated to us.

February 21-23	Versailles (France)	Congrès : Reconnaissance des Formes et Traitement des Images. organizers : Association Française pour la Cybernétique Economique et Technique (AFCET)/Institut de Recherche d'Informatique et d'Automatisme (IRIA).
February 26-March 3	Washington (U.S.A.)	American Congress on Surveying and Mapping/ASP Spring National Convention. (Cartography; photogrammetry; interpretation and remote sensing...). organizers : American Society of Photogrammetry/American Congress of Surveying and Mapping.
March 6-10	Toulouse (France)	Earth's Observation from Space and Management of Planetary Resources. organizers : O.S.T. B.P. 4130 18, avenue Edouard Belin 31030 TOULOUSE CEDEX (This conference is sponsored by EARSeL).
April 27-28	Munich (F.R.G.)	2nd EARSeL General Assembly organizer : Prof. J. BODECHTEL Zentralstelle für Geophotogrammetrie und Fernerkundung, Institut für allg. und angew. Geologie, Luisenstr. 27, 8 MUNCHEN 2
July 3-8	Freiburg (F.R.G.)	Remote Sensing for Exploration of the Earth, its Natural Resources and Endangered Biosphere (I.S.P. Commission VII) organizer : Prof.Dr. G. HILDEBRANDT Universität Abteilung Luftbildmessung und Luftbildinterpret, Erbprinzenstrasse 17a D 7800 FREIBURG i.Br.
September 12-14	Paris (France)	Symposium International sur les Equipements de Photogrammetrie Analytique et de Télédétection (ISP - Commission II) organizer : Dr. A. FONTANEL SIP Secretariat Commission II, 4, avenue du Bois-Préau, BP 311 92506 RUEIL MALMAISON CEDEX
September 78	Oxford (U.K.)	International Conference on Applications of Machine-Aided Image Analysis. organizer : Dr.David STANLEY B 521, Harwell Laboratory DIDCOT, Oxfordshire UK OX11 ORA

(*) EARSeL NEWS, August 1977, nr. 1.

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