Age determination of Norwegian minerals up to March 1964.

By
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Abstract.

A summary of absolute age determinations of Norwegian minerals and rocks up to March 1964. Map of localities, diagrams and analysis of the data. Major orogenies occurred at ~ 900, ~ 400 and possibly at ~ 575 m. y. K/Ar time, volcanogenies at 580 and ~ 250 m. y. Anorogeny occurred at 675 m. y. ±, after ~ 300 m. y., and possibly at 500 m. y. ±. Indistinct and uncertain events at ~ 2700, ~ 1800, (~ 1400), 1100 (– 1050) and 850–800 m. y. are discussed.

During the years 1958–64 absolute age determinations of biotite and muscovite separated from a number of Norwegian rocks were carried out by the "Laboratory for pre-Cambrian Geology" in Leningrad under the leadership of E. K. Gerling, S. V. Obruchev and A. A. Polkanov.

The late A. A. Polkanov, Academician, Director of the Laboratory for pre-Cambrian Geology, suggested in a letter dated 8th July 1958 to the director of the Geological Survey of Norway that cooperation between the Survey and the Laboratory might be started in order to provide certain geochronological data to be presented at the International Geological Congress in Copenhagen in 1960. The project soon materialized and work went on without much interruption for some time even after the Congress. However, it now seems necessary to bring it to a conclusion; at least a substantial reduction must be foreseen, since an intrinsic part of the original motivation obviously does not exist any more.

The present paper is a brief summing up with a few trivial remarks, but without any pretensions of exhaustive evaluation and utilization of the data presented. Some of these data have been published and commented on by Neumann (l.c.) and by Polkanov (l.c.).

Rock samples for age determinations were collected by the Survey, mostly in connection with routine field work. Further samples were obtained from museums and geologists outside the Survey. Excursions for the sole purpose of procuring samples could be made only to a very limited extent, therefore the collection is not as complete and systematic as one might wish. – The separation of micas and the alkali determinations were done by the Survey under the supervision of Mr. Chr. Dick Thorkildsen, geologist, and Mr. Roar Solli, analyst, respectively. The present writer was in charge of the provision of rock samples and the correspondance with the Laboratory in Leningrad. – As may be seen from the reports of the "Laboratory for pre-Cambrian Geology" (copied as tables no. 4, 5 and 6 in the present paper) the K/Ar-method was employed, in two instances controlled by Rb/Sr-measurement.

The localities of the samples are shown on the map fig. 2 as dots with age numbers (in m. y.). On the same map were, further, plotted (from Neuman's (l.c.) complete list of 1960) localities of other available age determinations carried out according to various methods by various investigators. (Only those marked by Neumann with an asterisk were included. – Regarding 776 m y. Kviteseid, and 882 m. y. Senomstad, see below.) To avoid congestion these age determinations were, unlike those of the Laboratory for pre-Cambrian Geology, not plotted individually and with age numbers, but summarily only, as circles *1–23*. It should be understood that the circles denote localities only, without any systematic grouping. Each of them was drawn with the one object of enclosing as many sample localities as possible without the circle getting unduly large.

This procedure obviously called for a list not only of the determinations from the Laboratory for pre-Cambrian Geology, but also for lists of other age determinations. Consequently tables 1 and 2 were prepared. The latter include all known absolute age determinations of Norwegian minerals (rocks), and may be regarded as a supplement to Neumann's complete list of 1960, which should be consulted by the reader for necessary details. Neumann (l.c.) also includes a discussion of the age determinations, as mentioned above.

Table 1. *Key to the circles on map fig. 2.*

For details consult Neumann's lists l.c. p. 174 and 189.

Circle *1* (Dab):	243 m. y. Thorite. Brevig. – 355 m. y. Thorite. Brevig. –
Circle *1 a* (Db):	565 m. y. Biotite. Fen, Holla, Telemark. – 585 m. y. Biotite. Near Fen, Holla, Telemark. –
Circle *2* (Db):	216 m. y. Zircon. Trondheimsveien, Oslo. – 235 m. y. Molybdenite. Sørumsåsen, Røyken. – 259 m. y. Zircon. Trondheimsveien, Oslo. – 259 m. y. Biotite. Skoglyst, Drammen. – 284 m.y. Biotite. Sande, Vestfold. –
Circle *3* (D (E) b):	1105 m. y. Biotite. Lørenskog, Oslo.
Circle *4* (DEb):	615 m. y. Molybdenite. Thoreby, Varteig. – 839 m. y. Biotite. Iddefjord, Østfold. – 920 m. y. Uraninite. Karlshus, Østfold. – 929 m. y. Biotite. Heller, Askim, Østfold. – 965 m. y. Muscovite. Hyttåsen, Hobøl, Østfold. –
Circle *5* (Dc):	950 m. y. Biotite. Hedal church, Oppland. –
Circle *6* (Db (c)):	700 m.y. Molybdenite. Rollag, Nummedal. – 709 m.y. do. do. – 895 m.y. Sericite. Bjertnes feldspar quarry, Krødsherad, Buskerud. – 1041 m.y. Phlogopite. Snarum, Buskerud. – 1055 m.y. Muscovite. Near Spone church, Modum, Buskerud. –
Circle *7* (Db):	965 m.y. Biotite. North of Tinnsjø, Telemark. –
Circle *8* (Cb):	862 m.y. Molybdenite. Kobbernuten, Bykle, Aust-Agder. –
Circle *9* (C (D) b):	621 m.y. Molybdenite. Tarjeisberg, Telemark. – 657 m.y. Molybdenite. Bandaksli, Telemark. – 676 m.y. Molybdenite. Riehammeren, Berge, Telemark. – 687 m.y. Molybdenite. Dalen, Telemark. – 691 m.y. do. do. – 915 m.y. Biotite. Tarjeisberg, Telemark. – 1560 m.y. Molybdenite. do. –
Circle *10* ((C) D (a) b):	880 m.y. Lepidolite. Tørdal, Telemark. – 900 m.y. do. do. – 950 m.y. Microcline. Tørdal. –
Circle *11* (CDa (b)):	815 m.y. Biotite. Sandå, s. Sundsli, Aust-Agder. –
Circle *12* (Dab):	450 m.y. Euxenite. Kalstad, Kragerø. – 530 m.y. do. do. – 940 m.y. do. do. – 980 m.y. do. do. – 1080 m.y. Biotite. Ødegården verk, Bamble, Telemark. –
Circle *13* (Da):	610 m.y. Thorite. Tvedestrand. – 679 m.y. Molybdenite Hosås, Risør. – 840 m.y. Cleveite. Auselmyr, Holt, Aust-Agder. – 850 m.y. Biotite. Fevik, Aust-Agder. – 850 m.y. Biotite. Amtmannsvingen, Aust-Agder. – 870 m.y. Biotite. Flaten, Aust-Agder. – 925 m.y. Biotite. Flaten, Aust-Agder. – 935 m.y. Biotite. Tromøysundet, Aust-Agder. – 940 m.y. Biotite. Assevvann, Aust-Agder. – 1010 m.y. Biotite. Hisøy, Aust-Agder. – 1040 m.y. Biotite. Langsev, Aust-Agder. – 1060 m.y. Cleveite. Auselmyr, Aust-Agder. – 1070 m.y. Cleveite. Auselmyr. – 1085 m.y. Cleveite. Auselmyr. – 1090 m.y. Cleveite. Auselmyr. – 1090 m.y. do. do. – 1105 m.y. Biotite. Hisøy, Aust-Agder. – 1110 m.y. Cleveite. Auselmyr. – 1345 m.y. Biotite. Langsev, Aust-Agder. –
Circle *14* (CDa):	860 m.y. Biotite. Landvik, Aust-Agder. –
Circle *15* (Ca):	755 m.y. Gadolinite. Frikstad, Iveland, Vest-Agder. – 820 m.y. do. do. – 860 m.y. Muscovite. Iveland. – 882 m.y. Molybdenite, Tveit, Iveland. – 884 m.y. Blomstrandine, Kåbuland, Iveland. – 920 m.y. Blomstrandine. Kåbuland, Iveland. – 962 m.y. Molybdenite. Tuftan, Iveland. –
Circle *16* (Ca):	485 m. y. Euxenite. Rømteland, Vest-Agder. – 495 m.y. Thorite. do. – 560 m.y. Euxenite. do. – 740 m.y. Thorite. do. – 759 m.y. Biotite. Remesvig, Vest-Agder. – 760 m.y. Thorite. Rømteland. – 825 m.y. Biotite. do. – 830 m.y. Thorite. do. – 890 m.y. Uraninite. do. – 892 m.y. Uraninite. do. – 900 m.y.

Uraninite. do. – 910 m.y. Euxenite. do. – 920 m.y. Uraninite. do. – 920 m.y. Euxenite. do. – 920 m.y. Uraninite. do. –
Circle *17* (Bc): 425 m.y. Muscovite. Kvamsvåg, Alversund, Hordaland. –
Circle *18* (Cd): 385 m.y. Biotite. Dalsnibba, Romsdal. – 405 m.y. Biotite. Geiranger, Romsdal. –
Circle *19* (C(D) d (e)): 540 m.y. Molybdenite. Rødsand, Møre. –
Circle *20* (Ac): 395 m.y. Muscovite. Bleikvassli, Nordland. –
Circle *21* (Ad): 565 m.y. Molybdenite. Oterstrand, Gildeskål, Nordland.–
Circle *22* (Ac): 2290 m.y. Molybdenite. Vatterfjord, Lofoten, Nordland. –
Circle *23* (Aef): 423 m.y. Biotite. Røshagen, Selvågfjord, Langøy, Vesterålen, Nordland. – 430 m.y. Biotite. Jægtbøgen, Langøy. – 450 m.y. Biotite. Storelva between Viksfjord and Geirsfjord, Langøy. – 575 m.y. Biotite. Between Sandnes and Sandnesodden, Langøy.

Table 2. *All known absolute age determinations (March 1964)* of Norwegian minerals; compare map, fig. 2 and diagram fig. 3, I.*

N = vide Neumann l.c. – L = determination carried out in the Laboratory for pre-Cambrian Geology, Leningrad. – Left out = age numbers not marked with an asterisk by Neumann and not plotted on the map fig. 1. – Circle *1*, *2* etc.: see table 1, above (and the map fig. 1). Letters A, B. . . a, b. . . etc. indicate position on the map fig. 1.

Note. *Herefoss* granite was formerly called Birkeland granite. *Fevik* granite is the same as Fevig, Fævig and Grimstad granite. The *Østfold* granite (in Sweden: *Bohus* granite), formerly Smålens-(Smaalens-) granite has many local and commercial names, such as Iddefjord, Fredrikstad, Fredrikshald granite a. o. *Flå* granite (Flaa granite); obsolete names: Ådal (Aadal), Sperillen granite.

(136 m.y. Larvik. Left out. N). – (160 m.y. Barkevik. Left out. N). – (166 m.y. Låven. Left out. N). – **216** m.y. Oslo. Circle *2*. Db. N., see table 7. – (231 m.y. Barkevik. Left out. N). – 235 m.y. Røyken. Circle *2*. Db. N. – **243** m.y. Brevig. Circle *1*. Dab. N., see table 7. – (244 m.y. Kragerø. Left out. N). – (250 m.y. Mørjefjord. Left out. N). – **259** m.y. Oslo. Circle *2*. Db. N., see table 7. – **259** m.y. Drammen. Circle *2*. Db. N., see table 7. – (269 m.y. Barkevik. Left out. N). – (279 m.y. Seiland. Left out. N). – **284** m.y. Sande. Circle *2*. Db. N., see table 7. – (285 m.y. Barkevik. Left out. N). – (294 m.y. Seiland. Left out. N). – (310 m.y. Vats. Left out. N). – **315** m.y. Langesundsfjord. 315, Dab. N. L., see table 7. – (329 m.y. Seut. Left out. N). – (331 m.y. Fredriksværn. Left out. N). – **346** m.y. Kjerringøy. 346, ABde. L. see table 7. – **355** m.y. Brevig. Circle *1*. Dab. N., see table 7. – **355** m.y. Ulsberg. 355, Dd.L., see table 7. – (365 m.y. Tellenes. Left out. N). – (366 m.y. Seiland. Left out. N). – **367** m.y. Kjerringøy. 367, ABde. L., see table 7. – **367** m.y. Oppdal. 367, Dd. L., see table 7. – **370** m.y. Oppdal. 370, Dd. L., see table 7. –
(373 m.y. Biotite from gneiss granite (granite?) with felspar insets (porphyric appearance), belonging to a body or complex predominantly consisting of gneiss or granite, with some intercalations of mafic rocks, forming, according to geological map (manuscript by the late Steinar Foslie, survey geologist) and aerial photos (Johannes Dons commun.), a circular-shaped geological unit within the pre-Cambrian area. The pre-Cambrian age of this rock has never been questioned. – South of the old church, at new road along south side of lake Kviteseid, Kviteseid, Telemark. 373, CDb. L. – Olaf Anton Broch leg. 1960., see remarks below. – (378 m.y., same sample as 373 m.y., above). –
381 m.y. Kjerringøy. 381 ABde. L., see table 7. – **385** m.y. Dalsnibba. Circle *18*. Cd. N., see table 7. – **388** m.y. Horg, Sør-Trøndelag. 388, Dd. L., see table 7. – (390 m.y. Tellenes. Left out. N). – **391** m.y. Kjerringøy. 391 ABde. L., see table 7. – **395** m.y.

* See, however, "Addendum", p. 111.

Bleikvassli. Circle *20*. Ac. N., – see table 7. – **405** m.y. Namsskogan. 405, Ef. N. L., see table 7. – **405** m.y. Geiranger. Circle *18* Cd. N., see table 7. – **413** m.y. Telavåg. 413, Bbc. L., see table 7. – (413 m.y. Fen. Left out. N). – (420 m.y. Fen. Left out. N). – **423** m.y. Røshagen. Circle *23*. Aef. N., see table 7. – **425** m.y. Kvamsvåg. Circle *17*. Bc. N., see table 7. – **430** m.y. Jægtbøgen. Circle *23*. Aef. N., see table 7. – (430 m.y. Kragerø. Left out. N). – **434** m.y. Tveit, Sotra. 434, Bbc. N.L., see table 7. – (437 m.y. Lakssvelefjell. Left out. N). – 450 m.y. Kalstad. Circle *12*. Dab. N. – **450** m.y. Laksevåg. 450, Bbc. N. L., see table 7. – (460 m.y. Fen. Left out. N). – (484 m.y. Rømteland. Left out. N). – 485 m.y. Rømteland. Circle *16*, Ca. N. – 495 m.y. Rømteland. Circle *16*, Ca. N. – (501 m.y. Råde. Left out. N). – (508 m.y. Ålgård. Left out. N). – (520 m.y. Stjernø. Left out. N). – 530 m.y. Kalstad. Circle *12*, Dab. N. – (530 m.y. Fen. Left out. N). – 540 m.y. Rødsand (= Rausand). Circle *19*, C (D) d (c). N. – **550** m.y. Fåberg. 550, Dc. L., see table 7. – (560 m.y. Rømteland. Left out. N). – 560 m.y. Rømteland. Circle *16*, Ca. N. – (560 m.y. Bygdin. Left out. N). – 565 m.y. Gildeskål. Circle *21*, Ad. N. – **565** m.y. Fen. Circle *1a*, Db. N., see table 7. – **568** m.y. Fen. 568, Db. L., see table 7. – (570 m.y. Fen. Left out. N). – **573** m.y. Fen. 573, Db. L., see table 7. – **575** m.y. Langsev. Circle *23*, Aef. N., see table 7. – **582** m.y. Loen. 582, Cd. N. L., see table 7. – **585** m.y. Fen. Circle *1a*, Db. N., see table 7. – (587 m.y. Spangereid. Left out. N). – **590** m.y. Fen. 590, Db. N. L., see table 7. – **590** m.y. Ortnevik. 590, Cc. N. L., see table 7. – (590 m.y. Fen. Left out. N). – **603** m.y. Fen. 603, Db. N. L., see table 7. – 610 m.y. Tvedestrand. Circle *13*, Da. N. – (613 m.y. Iddefjord. Left out. N). – 615 m.y. Thoreby. Circle *4*, DEb. N. – 621 m.y. Tarjeisberg. Circle *9*, C(D) b. N. – (640 m.y. Torset. Left out. N). – (650 m.y. Følstad. Left out. N.) – 657 m.y. Bandaksli. Circle *9*, C(D) b. N. – (672 m.y. Hobøl. Left out. N). – 676 m.y. Riehammeren. Circle *9*, C(D) b. N. – 679 m.y. Hosås. Circle *13*, Da. N. – 687 m.y. Dalen. Circle *9*, C(D) b. N. – 691 m.y. Dalen. Circle *9*, C(D) b. N. – 700 m.y. Rollag. Circle *6*, Db(c). N. – 709 m.y. Rollag. Circle *6*, Db(c). N. – (720 m.y. Solberg. Left out. N). – **755** m.y. Frikstad. Circle *15*, Ca. N., see table 7. – **758** m.y. Totakvann. 758, Cb. L., see table 7. – **759** m.y. Remesvik. Circle *16*, Ca. N., see table 7. – 760 m.y. Rømteland. Circle *16*, Ca. N. – (760 m.y. Solberg. Left out. N). – **772** m.y. Totakvann. 772, Cb. N.L., see table 7. – **776** m.y. Onsøy. 776, DEb. N.L., see table 7. –

776 m.y. Kviteseid (Neumann l. c. writes 777 m.y. – obviously a slip). The value seems to be wrong and was replaced by 842, see remarks below.

802 m.y. Tune. 802, DEb. N.L., see table 7. – (804 m.y. Stavanger. Left out. N). – (812 m.y. Askim. Left out. N). – **815** m.y. Sundsli. Circle *11*, CDa(b). N., see table 7. – **815** m.y. Ualand. 815, Ca. L., see table 7. – **820** m.y. Frikstad. Circle *15*, Ca. N., see table 7. – **823** m.y. Tune ("Iddefjord", Neumann l. c., is wrong; read "Solli church, Tune"). 823, DEb. N. L., see table 7. – **824** m.y. Gol. 824, Dc. N. L., see table 7. – 825 m.y. Rømteland. Circle *16*, Ca. N. – **828** m.y. Landvik. 828, CDa. L., see table 7. – 830 m.y. Rømteland. Circle *16*, Ca. N. – (830 m.y. Næs. Left out. N). – **836** m.y. Landvik. 836, CDa. L., see table 7. – **839** m.y. Iddefjord. Circle *4*, DEb. N., see table 7. – 840 m.y. Auselmyren. Circle *13*, Da. N. – **842** m.y. Kviteseid (cp. 776 m.y. above). 842, CDb. N. L., see table 7. – **850** m.y. Fevik. Circle *13*, Da. N., see table 7. – **850** m.y. Amtmannsvingen. Circle *13*, Da. N., see table 7. – **852** m.y. Bjertnes. 852 Dbc. N. L., see table 7. – **857** m.y. Gol. 857, Dc. N. L., see table 7. – **860** m.y. Iveland. Circle *15*, Ca. N., see table 7. – **860** m.y. Herefoss. Circle *14*, CDa. N., see table 7. – **861** m.y. Herefoss. 861, CDa. L., see table 7. – 862 m.y. Kobbernuten. Circle *8*, Cb. N. – **864** m.y. Ualand. 864, Ca. L., see table 7. – **868** m.y. Gol. (869 m.y., Neumann l. c., is a slip, read 868). 868, Dc.N.L., see table 7. – **870** m.y. Flaten. Circle *13*, Da. N., see table 7. – **874** m.y. Øyestad. 874, CDa. N.L., see table 7. – (879 m.y. Magnor. Left out. N). – **880** m.y. Iveland. 880, Ca.N.L., see table 7. – **880** m.y. Tørdal. Circle *10*, (C) D (a) b. N., see table 7. – 882 m.y. Tveit. Circle *15*, Ca. N. – **884** m.y. Kåbuland. Circle *15*, Ca. N., see table 7.

882 m.y. Herefoss. This value is probably wrong and was replaced by 975 m.y., see remarks below.

890 m.y. Ål. 890, CDc. N. L., see table 7. – 890 m.y. Rømteland. Circle *16*, Ca. N. – 892 m.y. Rømteland. Circle *16*, Ca. N. – **895** m.y. Bjertnes. Circle *6*, Db (c). N., see table 7. – (895 m.y. Hobøl. Left out. N). – 900 m.y. Rømteland. Circle *16*, Ca. N. –

900 m.y. Tørdal. Circle *10*, (C) D (a) b. N., see table 7. – **900** m.y. Eide (Landvik). 900, CDa. N. L., see table 7. – **904** m.y. Vats. 904, BCb. N. L., see table 7. – **904** m.y. Lauvrak, CDa. N. L., see table 7. – **905** m.y. Herefoss. 905, CDa. N. L., see table 7. – (910 m.y. Skarvvann. Left out). – 910 m.y. Rømteland. Circle *16*, Ca. N. – **915** m.y. Tarjeisberg. Circle *9*, C(D) b. N., see table 7. – **920** m.y. Rømteland. Circle *16*, Ca. N., see table 7. – **920** m.y. Rømteland. Circle *16*, Ca. N., see table 7. – **920** m.y. Rømteland. Circle *16*, Ca. N., see table 7. – **920** m.y. Kåbuland. Circle *15*, Ca. N., see table 7. – **920** m.y. Karlshus. Circle *4*, DEb. N., see table 7. – **924** m.y. Brandval. 924, Ebc. L., see table 7. – **925** m.y. Flaten. Circle *13*, Da. N., see table 7. – **927** m.y. Landvik. 927, CDa. N. L., see table 7. – **927** m.y. Gulsvik. 927, Dbc. N. L., see table 7. – **929** m.y. Askim. Circle *4*, DEb. N., see table 7. – **930** m.y. Landvik. 930, CDa. N. L., see table 7. – **930** m.y. Landvik. 930, CDa. N. L., see table 7. – (930 m.y. Seiland. Left out. N). – **935** m.y. Tromøysund. Circle *13*, Da. N., see table 7. – **936** m.y. Brandval. 936, Ebc. L., see table 7. – **940** m.y. Assevvann. Circle *13*, Da. N., see table 7. – **940** m.y. Kalstad. Circle *12*, Dab. N., see table 7. – **943** m.y. Sør-Aurdal. 943, Dc. N. L., see table 7. – **946** m.y. Rakkestad. 946, Eb. N. L., see table 7. – **950** m.y. Hedal. Circle *5*, Dc. N., see table 7. – **950** m.y. Tørdal. Circle *10*, (C) D (a) b. N., see table 7. – **952** m.y. Ådal. 952, Db (c). N. L., see table 7. – **956** m.y. Landvik. 956, CDa. N. L., see table 7. – 962 m.y. Tuftan. Circle *15*, Ca. N. – **965** m.y. Tinnsjø. Circle 7, Db. N., see table 7. – **965** m.y. Hyttåsen. Circle *4*, DEb. N., see table 7. – **966** m.y. Landvik. 966, CDa. N. L., see table 7. – (968 m.y. Karlshus. Left out. N). – **970** m.y. Lauvrak. 970, CDa. N. L., see table 7. – (970 m.y. Tarjeisberg. Left out. N). – **975** m.y. (see 882 m.y. above). Herefoss. 975, C(D)a. N. L., see table 7. – **977** m.y. Bjertnes. 977, Dbc. N. L., see table 7. – **980** m.y. Kalstad. Circle *12*, Dab. N., see table 7. – **990** m.y. Krødsherad. 990, Db(c). N. L., see table 7. – **990** m.y. Herefoss. 990, C(D)a. N. L., see table 7. – **1007** m.y. Herefoss (same sample as 990 m.y., it was by accident not plotted on the map fig. 1). – **1010** m.y. Hisøy. Circle *13*, Da. N., see table 7. – (1011 m.y. Karlshus. Left out. N). – **1016** m.y. Holla. 1016, Db. N. L., see table 7. – (1018 m.y. Arendal. Left out. N). – (1020 m.y. Arendal. Left out. N). – **1030** m.y. Øyestad. 1030, CDa. N. L., see table 7. – **1030** m.y. Rakkestad. 1030, Eb. L., see table 7. – **1040** m.y. Langsev. Circle *13*, Da. N., see table 7. – **1041** m.y. Snarum. Circle *6*, Db(c). N., see table 7. – (1043 m.y. Iveland. Left out. N). – **1048** m.y. Norderhov. 1048, Dbc. N. L., see table 7. – **1052** m.y. Norderhov. 1052, Dbc. N. L., see table 7. – **1055** m.y. Spone. Circle *6*, Db(c). N., see table 7. – **1060** m.y. Auselmyra. Circle *13*, Da. N., see table 7: 1085 m.y. – **1070** m.y. Auselmyra. Circle *13*, Da. N., see table 7: 1085 m.y. – **1080** m.y. Ødegården. Circle *12*, Dab. N., see table 7. – **1085** m.y. Auselmyra. Circle *13*, Da. N., see table 7. – **1090** m.y. Auselmyra. Circle *13*, Da. N., see table 7: 1085 m.y. – **1090** m.y. Auselmyra. Circle *13*, Da. N., see table 7: 1085 m.y. – **1105** m.y. Hisøy. Circle *13*, Da. N., see table 7. – **1105** m.y. Lørenskog. Circle *3*, D(E)b. N., see table 7. – **1110** m.y. Auselmyra. Circle *13*, Da. N., see table 7: 1085 m.y. – **1148** m.y. Rakkestad. 1148, (D) Eb. L., see table 7. – (1193 m.y. Aust-Agder. Left out. N). – (1251 m. y. Auselmyra. Left out. N). – (1254 m.y. Arendal. Left out. N). – **1261** m.y. Hesnes. 1261, CDa. L., see table 7. – (1269 m.y. Auselmyra. Left out. N). – (1283 m.y. Auselmyra. Left out.N). – (1294 m.y. Auselmyra. Left out. N). – (1300 m.y. Hitterø. Left out. N). – (1308 m.y. Auselmyra. Left out. N). – **1345** m.y. Langsev. Circle *13*, Da. N., see table 7. – 1560 m.y. Tarjeisberg. Circle *9*, C(D)b. N. – (1620 m.y. Tarjeisberg. Left out. N). – (1640 m.y. Bjertnes. L., Olaf Anton Broch leg. 1958. Left out, cp. remarks below). – **1650** m.y. Iveland. 1650, Ca. L., see table 7 and remarks below. – (1690 m.y. Bjertnes. L. Left out, cp. remarks below). – **1750** m.y. Iveland. 1750, Ca. L., see remarks below, and table 7. – (2080 m.y. Lofoten. Left out. N). – **2290** m.y. Vatterfjord. Circle *22*, Aef. N., see table 7: 2750 m.y., and remarks (on Re/Os ages). –

Table 3. *Alkali determinations by Roar Solli, Laboratory of the Geological Survey of Norway.*

		Na_2O	K_2O	Total
315.	Lepidomelan. Langesundsfjord*			
346.	Biotite. Barbrahei	0,18	8,98	9,2
355.	Biotite. Ulsberg	0,21	8,62	8,8
367.	Biotite. Kroksviken	0,21	8,76	9,0
367.	Biotite. Stekeren	0,27	8,98	9,1
370.	Biotite. Lønset	0,10	9,40	9,5
373.	Biotite. Kviteseid	0,12	0,41	9,5
378.	(= 373. Kviteseid)	–	–	–
381.	Muscovite. Barbrahei	0,63	10,09	10,7
388.	Biotite. Lønset	0,12	9,58	9,7
391.	Biotite. Låtetind	0,09	8,96	9,1
405.	Biotite. Tverrådalen	0,49	8,00	8,5
413.	Muscovite. Telavåg	0,90	9,24	10,1
434.	Biotite. Tveit	0,11	6,34	6,5
450.	Muscovite. Liavann	0,73	5,86	6,6
550.	Shale. Fåberg*	–	–	–
568.	Biotite. Fen	0,24	9,26	9,5
573.	Biotite. Fen	0,63	8,09	8,7
582.	Muscovite. Loen	0,67	10,17	10,8
590.	Biotite. Fen	0,15	6,71	6,9
590.	Muscovite. Ortnevik	0,44	9,97	10,4
603.	(= 590. Fen)	–	–	–
758.	Biotite. Araodden	0,10	5,55	5,7
772.	Biotite. Araodden	0,15	7,95	8,1
776.	Biotite. Onsøy	0,19	7,54	7,7
776**	Biotite. Kviteseid	1,20	9,10	10,3
802.	Biotite. Solli	0,47	5,90	6,4
815.	Biotite. Ualand	0,29	8,63	8,9
823.	(= 802. Solli)	–	–	–
824.	Biotite. Gol	0,24	8,23	8,5
828.	Biotite. Bruna	0,21	8,88	10,1
836.	(= 828. Bruna)	–	–	–
852.	Biotite. Bjertnes	0,44	7,39	7,8
857.	Biotite. Gol	0,36	7,88	8,2
861.	Biotite. Åmli	0,82	7,06	7,9
864.	Biotite. Ualand	0,54	7,48	8,0
868.	(= 857. Gol)	–	–	–
874.	Biotite. Øyestad	0,45	6,06	6,5
880.	Biotite. Håvardstad	2,56	4,60	7,2
882**	Biotite. Sennomstad	0,17	6,96	7,1
890.	Biotite. Ål	0,56	8,69	9,3
900.	Biotite. Omre	0,69	5,93	6,6
904.	Muscovite. Vats	1,81	9,84	11,7
904.	Biotite. Løvrak	0,71	10,00	10,7
905.	Muscovite. Åmli	0,59	10,11	10,7
924.	Biotite. Øyerberget	0,33	10,21	10,5
927.	Biotite. Grøsle	0,35	8,60	9,0

* Alkalies determined in the Laboratory for pre-Cambrian Geology, Leningrad.

** 776 should be 842; 882 should be 975 – cp. remarks p. 97–98.

		Na_2O	K_2O	Total
927.	Biotite. Gulsvik	0,35	5,42	5,8
930.	Biotite. Killandsvann	0,14	7,36	7,5
930.	(= 927. Grøsle)	–	–	–
936.	(= 924. Øyerberget)	–	–	–
943.	Biotite. Ospeholt	0,41	2,03	2,4
946.	Muscovite. Nordby	0,64	10,29	10,9
952.	Biotite. Gryte	0,43	6,28	6,7
956.	Biotite. Grøsle	0,19	7,21	7,4
966.	(= 927. Grøsle)	–	–	–
970.	Muscovite. Løvrak	0,86	8,86	9,7
977.	Muscovite. Bjertnes	0,68	9,78	10,5
990.	Biotite. Hamremoen	0,76	6,19	7,0
990.	Biotite. Hanefoss	0,69	5,93	6,6
1007.	(= 990. Hanefoss)	–	–	–
1016.	Biotite. Valebø	1,04	4,71	5,8
1030.	Biotite. Øyestad	1,18	6,74	7,9
1030.	(= 946. Nordby)	–	–	–
1048.	Biotite. Heradsbygd	0,19	9,05	9,2
1052.	Muscovite. Heradsbygd	1,08	8,41	9,5
1148.	Biotite. Nordby	0,11	6,70	6,8
1261.	Biotite. Bruvollen	0,08	5,82	5,9
1640.	Muscovite. Bjertnes	7,86	3,42	11,3
1650.	Biotite. Eptevann	0,23	6,88	7,1
1690.	(= 1640. Bjertnes)	–	–	–
1750.	(= 1650. Eptevann)	–	–	–

Table 4. *K-A Dates on micas from the pre-Cambrian rocks of Norway carried out in the Laboratory of pre-Cambrian Geology.*

(Sent with letter dated 4th April 1960.)

N Laboratory	N Norway	Mineral	Kg/g	K^{40}g/g	A см³ /g	A g/g	A^{40}/K^{40}	10^6
1086	A 1	Bt	0.0660	$8.05.10^{-6}$	$2.34.10^{-4}$	$4.19.10^{-7}$	0.0520	772
1087	A 2	Bt	0.0599	$7.19.10^{-6}$	$2.79.10^{-4}$	$4.99.10^{-7}$	0.0683	956
1198	A 3	Bt	0.0634	$7.74.10^{-6}$	$2.85.10^{-4}$	$5.10.10^{-7}$	0.0659	930
1199	A 4	Bt	0.0661	$8.06.10^{-6}$	$2.79.10^{-4}$	$4.99.10^{-7}$	0.0619	882
1144	A 5	Bt	0.0492	$6.00.10^{-6}$	$2.39.10^{-4}$	$4.27.10^{-7}$	0.0713	990
					$2.45.10^{-4}$	$4.38.10^{-7}$	0.0730	1007
1148	A 6	Mica	0.0560	$6.83.10^{-6}$	$2.87.10^{-4}$	$5.13.10^{-7}$	0.0751	1030
1195	A 7	Mica	0.0691	$8.43.10^{-6}$	$2.96.10^{-4}$	$5.30.10^{-7}$	0.0628	900
1142	A 8	Bi	0.0751	$9.16.10^{-6}$	$3.93.10^{-4}$	$7.04.10^{-7}$	0.0768	1048
1143	A 8	Mu	0.0698	$8.52.10^{-6}$	$3.67.10^{-4}$	$6.57.10^{-7}$	0.0771	1052
1141	A 9	Bi	0.0514	$6.27.10^{-6}$	$2.50.10^{-4}$	$4.48.10^{-7}$	0.0713	990
1145	A 10	Mica	0.0450	$5.49.10^{-6}$	$2.01.10^{-4}$	$3.61.10^{-7}$	0.0657	927
1140	A 12	Bi	0.0654	$8.00.10^{-6}$	$2.70.10^{-4}$	$4.84.10^{-7}$	0.0605	868
					$2.65.10^{-4}$	$4.74.10^{-7}$	0.0595	857

(Continued next page)

1200	A 13	Bi	0.0683	$8.34.10^{-6}$	$2.64.10^{-4}$	$4.72.10^{-7}$	0.0566	824
1196	A 14	Mica	0.0721	$8.80.10^{-6}$	$3.07.10^{-4}$	$5.49.10^{-7}$	0.0625	890
1201	A 16	Mica	0.0521	$6.30.10^{-6}$	$2.41.10^{-4}$	$4.31.10^{-7}$	0.0679	952
1202	A 17	Mica	0.0169	$2.06.10^{-6}$	$7.72.10^{-5}$	$1.38.10^{-7}$	0.0672	943
1139	A 18	Bi	0.0557	$6.80.10^{-6}$	$1.48.10^{-4}$	$2.65.10^{-7}$	0.0390	603
					$1.46.10^{-4}$	$2.60.10^{-7}$	0.0381	590
1203	A 20	Bi	0.0391	$4.77.10^{-6}$	$1.97.10^{-4}$	$3.52.10^{-7}$	0.0738	1016
1088	A 23	Bt	0.0664	$8.10.10^{-6}$	$1.13.10^{-4}$	$2.01.10^{-7}$	0.0248	405
1204	A 30	Mica	0.0382	$4.66.10^{-6}$	$1.60.10^{-4}$	$2.86.10^{-7}$	0.0615	880
1146	A 32	Mica	0.0626	$7.64.10^{-6}$	$2.25.10^{-4}$	$4.02.10^{-7}$	0.0547	776
1205	A 33	Mica	0.0490	$5.97.10^{-6}$	$1.82.10^{-4}$	$3.25.10^{-7}$	0.0547	802
					$1.89.10^{-4}$	$3.38.10^{-7}$	0.0566	823
1230	A 35	Mu	0.0735	$8.97.10^{-6}$	$3.49.10^{-4}$	$6.26.10^{-7}$	0.0698	970
1210	A 36	Mica	0.0830	$1.01.10^{-5}$	$3.00.10^{-4}$	$5.36.10^{-7}$	0.0529	776
1227	A 38	Mu	0.0810	$9.88.10^{-6}$	$3.87.10^{-4}$	$6.94.10^{-7}$	0.0702	977
1229	A 37	Mu	0.0854	$1.04.10^{-5}$	$3.91.10^{-4}$	$7.00.10^{-7}$	0.0672	946
1206	A 39	Mica	0.0830	$1.01.10^{-5}$	$3.60.10^{-4}$	$6.44.10^{-7}$	0.0636	904
1197	A 40	Bi	0.0714	$8.71.10^{-6}$	$3.19.10^{-4}$	$5.71.10^{-7}$	0.0656	927
					$3.20.10^{-4}$	$5.72.10^{-7}$	0.0657	930
								966 $\text{II}0\frac{\text{Rb}\,87}{\text{Sr}\,87}$
1208	A 41	Bi	0.0503	$6.14.10^{-6}$	$2.09.10^{-4}$	$3.74.10^{-7}$	0.0609	874
1226	A 42	Mu	0.0844	$1.03.10^{-5}$	$2.16.10^{-4}$	$3.86.10^{-7}$	0.0375	582
1207	A 44	Mica	0.0828	$1.01.10^{-5}$	$2.15.10^{-4}$	$3.84.10^{-7}$	0.0380	590
1228	A 46	Mu	0.0838	$1.02.10^{-5}$	$3.65.10^{-4}$	$6.53.10^{-7}$	0.0638	905
1209	A 47	Bi	0.0526	$6.42.10^{-6}$	$9.59.10^{-4}$	$1.72.10^{-7}$	0.0267	434
1211	A 48	Bi	0.0614	$7.48.10^{-6}$	$2.47.10^{-5}$	$4.42.10^{-7}$	0.0592	852
1231	A 49	Mu	0.0486	$5.92.10^{-6}$	$9.22.10^{-5}$	$1.65.10^{-7}$	0.0279	450
1225	A 50	Mu	0.0817	$9.96.10^{-6}$	$3.57.10^{-4}$	$6.38.10^{-7}$	0.0641	904
1219		Lepido-melane	0.0712	$8.69.10^{-6}$	$9.14.10^{-4}$	$1.64.10^{-7}$	0.0188	315

The following constants were used for the calculations:

weight relation $\frac{K_{49}}{K^{39} + K^{41}} = 1.22.10^{-4}$

$\lambda_{\varkappa} = 5{,}5.10^{-11}$ y.$^{-1}$

$\lambda_{\beta} = 4{,}72.10^{-10}$ y.$^{-1}$

The director of the Laboratory of Precambrian Geology,

Academician A. A. Polkanov (sign.). –

Professor E. K. Gerling (sign.)

Table 5.

Sent with letter dated 24th September 1963.

No.	Sample	Localities	Kg/g	K^{40} g/g	A^{40} см³/g	A^{40} g/g	A^{40}/K^{40}	Age (m.y.)
2585	A 25 Norwegian	Biotite from norite about 200 m SW of A 24 (Chr. D. Thorkildsen leg. 1959)	0,0716	$8.73.10^{-6}$	$2.73.10^{-4}$	$4.88.10^{-7}$	0.0559	815
2586	A 29 Norwegian	Biotite from pegmatite, Bruvollen, Hesnes, Grimstad. S-Norway (O. A. Broch leg. 1958)	0,0483	$5.89.10^{-6}$	$3.24.10^{-4}$	$5.80.10^{-7}$	0.0984	1261
2587	A 54 Norwegian	Muscovite from pegmatitic rock, Telavag, W. Norway (A. Kvale ded. 1959)	0.0757	$9.24.10^{-6}$	$1.31.10^{-4}$	$2.34.10^{-7}$	0.0254	413
2588	A 65 B Norwegian	Muscovite from Caledonian granitic gneis, Kjerringøy N. Norway (Chr. D. Thorkildsen leg. 1960) (a and b from the same sample)	0.0837	$1.02.10^{-5}$	$1.32.10^{-4}$	$2.36.10^{-7}$	0.0231	381
2589	A 66 Norwegian	Biotite from granite some km W of No. A 65 (Chr. D. Thorkildsen leg. 1960)	0.0727	$8.87.10^{-6}$	$1.10.10^{-4}$	$1.97.10^{-7}$	0.0222	367
2590	A 67 Norwegian	Biotite from gneis, about 5 km N of No. A 65 (Chr. D. Thorkildsen leg. 1960)	0.0744	$9.07.10^{-6}$	$1.21.10^{-4}$	$2.16.10^{-7}$	0.0238	391

(Continued next page)

(Table 5, cont.)

2592	A 24 Norwegian	Biotite from norite, Road No. 440, 2 km S from Ualand railway st., Egersund area (Chr. D. Thorkildsen leg. 1959)	0.0621	$7.58.10^{-6}$	$2.54.10^{-4}$	$4.55.10^{-7}$	0.0600	864
2593	A 26 Norwegian	Biotite from pegmatite, Åmli, Herefoss. South-Norway ("Bamble-formation") (O. A. Broch leg. 1958)	0.0586	$7.15.10^{-6}$	$2.39.10^{-4}$	$4.28.10^{-7}$	0.0598	861
2594	A 27 Norwegian	Biotite from pegmatite, Nordby Rakkestad, Østfold, S-E Norway (O. A. Broch leg. 1958)	0.0556	$6.78.10^{-6}$	$3.27.10^{-4}$	$5.86.10^{-7}$	0.0864	1148
2595	A 28 Norwegian	Biotite from pegmatite, Eptevann, Setesdal. S-Norway. (O. A. Broch leg. 1958)	0.0571	$6.96.10^{-6}$	$6.11.10^{-4}$ $5.59.10^{-4}$	$1.09.10^{-6}$ $1.00.10^{-6}$	0.157 0.144	1750 1650
2597	A 43 Norwegian	Muscovite from pegmatite, Bjertnes, Krødsherad, "Telemark-formation". (O. A. Broch leg. 1958)	0.0284	$3.46.10^{-6}$	$2.90.10^{-4}$ $2.76.10^{-4}$	$5.19.10^{-7}$ $4.94.10^{-7}$	0.150 0.143	1690 1640
2598	A 45 Norwegian	Biotite from sövite, Fen-area. (T. Siggerud ded. 1959)	0.0769	$9.38.10^{-6}$	$1.91.10^{-4}$	$3.42.10^{-7}$	0.0364	568

Director of Laboratory of Precambrian Geology

S. V. Obruchev (sign.)

Corresp.-member of the Academy of Science of USSR

Professor E. K. Gerling (sign.)

Table 6.

No. П.П.	Автор образца и его хар-ка	Местонахождение и геол. возраст	K г/г	K^{40} г/г	A^{40} см³/г	A^{40} г/г	A^{40}/K^{40}	Возраст в 10^6 лет
2591	A 19 Norway	Biotite from damtjernite, Fen area. Telemark. (S. Bergstöl leg. 1959)	0.0671	$8.18.10^{-6}$	$1.68.10^{-4}$	$3.02.10^{-7}$	0.0368	573
2596	A 31 Norway	Biotite from pegmatite, Bruna, Rorevann. Near Grimstad, S-Norway. (O. A. Broch leg. 1958)	0.0737	$8.98.10^{-6}$	$2.90.10^{-4}$ $2.71.10^{-4}$	$5.19.10^{-7}$ $5.01.10^{-7}$	0.0578 0.0561	836 828
2599	A 53 Norway	Biotite from pegmatite, Araodden, Telemark, cp. A 1.	0.0461	$5.62.10^{-6}$	$1.60.10^{-4}$	$2.86.10^{-7}$	0.0510	758
2600	A 60 Norway	Biotite from hypersthene-mica-diorite. Orkdal bro, Ulfsberg, S Trøndelag. (Caledonian intrusive) (P. Holmsen leg. 1960)	0.0715	$8.72.10^{-6}$	$1.05.10^{-4}$	$1.88.10^{-7}$	0.0215	355
2601	A 61 Norway	Biotite from augengneis, Stekeren profile, Road 640, S Trøndelag. (Caledonian metamorphic rock) (P. Holmsen leg. 1960)	0.0780	$9.52.10^{-6}$	$1.20.10^{-4}$	$2.14.10^{-7}$	0.0225	370

(Continued next page)

(Table 6, cont.)

2602	A 62 Norway	Biotite from basal gneis, Lønset, Oppdal, Road 640. Basal complex of caledonides. (P. Holmsen leg. 1960)	0.0795	$9.70.10^{-6}$	$1.28.10^{-4}$	$2.29.10^{-7}$	0.0236	388
2603	A 63 Norway	Biotite from micaceous gneis, Stekeren profile, Road 640, Oppdal. (P. Holmsen leg. 1960)	0.0745	$9.09.10^{-6}$	$1.13.10^{-4}$	$2.02.10^{-7}$	0.0222	367
2604	A 64 Norway	Biotite from gneisgranitic rock with feldspar insets. New road south of Kviteseid old church. (O. A. Broch leg. 1960)	0.0781	$9.52.10^{-6}$	$1.23.10^{-4}$ $1.21.10^{-4}$	$2.19.10^{-7}$ $2.16.10^{-7}$	0.0230 0.0227	378 373
2605	A 65 a Norway	Biotite from Caledonian granitic gneis, Kjerringøy, N. Norway (Chr. D. Thorkildsen leg. 1960)	0.0745	$9.09.10^{-6}$	$1.06.10^{-4}$	$1.89.10^{-7}$	0.0208	346
2606	A 68 Norway	Biotite from gneis, Øyerberget, E of Kongsvinger, near the Swedish border. (Chr. D. Thorkildsen leg. 1960)	0.0847	$1.03.10^{-5}$	$3.77.10^{-4}$ $3.85.10^{-4}$	$6.77.10^{-7}$ $6.88.10^{-7}$	0.0655 0.0666	924 936

14th February 1964.

E. K. Gerling (sign.)

Remarks.

Attention is drawn to a few age values among those received from Leningrad after the publication of Neumann's complete list of 1960 since they are exceptional and partly perplexing.

1640–1690 m. y. (same sample[1]), muscovite from pegmatite, Bjertnes in Krødsherad. This age conflicts with 852, 895, 977 m. y. determined on biotite, sericite, muscovite, respectively, from the same pegmatite dyke. Such an apparent age would furthermore hardly fit the picture formed by the overwhelming majority of determinations from the pre-Cambrian localities of S. Norway. According to alkali determination (Table 3) the composition of this muscovite would be most unusual. Some error has probably been made or some special explanation is needed, which cannot be offered at present. This age value will not be considered in the sequel.

1261 m. y. Biotite from pegmatite, Hesnes by Grimstad. In the absence of better evidence this pegmatite was looked upon as connected with the Fevik granite (~ 900 m. y. ?), according to its locality and appearance. The biotite has a bleached appearance and has a somewhat low alkali content.

1650–1750 m. y. (biotite from pegmatite, Eptevann in Iveland, Setesdal) is an unexpectedly high value – cp. other values from Setesdal pegmatites, namely 755, 820, 860, 880, 882, 884, 920, 962. The potassium content of the biotite is low, though (like that of 1261 above) not lower than in samples from certain localities giving "normal" – or perhaps even low – ages; e. g. 758 Araodden, 861 Åmli.

1148 m. y. Biotite from pegmatite, Nordby in Rakkestad, may perhaps be mentioned in this connection. From this locality ages of 946 m. y. K/Ar time and 1030 m. y. Rb/Sr time were recorded previously (with muscovite).

378–373 m. y. Biotite from granite, Kviteseid. The pre-Cambrian age of this rock has never been questioned. No comment shall be offered before control determination[2] has been undertaken on other samples from the same locality.

776 m. y. Biotite from pegmatite, Kviteseid, Telemark. This value is obviously not correct. According to the report from the Laboratory for

[1] Numbers connected by a hyphen (–) are ages determined on the same sample.

[2] S. V. Obruchev, Academician, present director of the Laboratory for pre-Cambrian Geology in Leningrad has kindly promised his help.

pre-Cambrian Geology (see Table no. 4, sample 1210 = A 36) the Kg/g value used is 0,0830, corresponding to ~ 10 per cent K_2O. But the K_2O content (Table 3) is actually 9,1 per cent. This latter value corresponds to 842 m. y., calculating with the same constants as those used in the Leningrad laboratory.

882 m. y. Biotite from granite, Senomstad (sample 1199 = A 4). The correct value of K_2O is 6,96 per cent. It seems as if the value 7,96 has been used. Thus 882 m. y. should be amended to 975 m. y.

The maps fig. 2 and, especially, fig. 4 mainly illustrate the slightly disappointing fact that, disregarding the distribution of the "ages" over the main field-geological units, i. e. pre-Cambrian and post-pre-Cambrian, (the latter subdivided into Caledonian, Fen and Oslo areas,) no realistic geographical pattern can at present be discerned. (Whether the existing localization of the majority of the four-digit figures within the Kongsberg–Bamble and the South-eastern areas is more than mere coincidence can only be decided by future investigations; cp. map fig. 1).

It seems therefore, that a scrutiny of the distribution of the "ages" in *time* may be the most profitable way of utilizing the data today. A preliminary attempt by means of diagrams follows below.

The diagrams. Diagrams were prepared in order to get a clearer picture, or at least one that would catch the eye better, than the mere list of numbers. In the diagrams fig. 3, recorded apparent ages were plotted against time, the curves showing number of ages per 100 m. y. (frequency curves). – An attempt to interpret such curves must be a quasi- or semi-statistical procedure and may as such have its pitfalls; I can only hope that the few steps to be taken in the sequel towards an interpretation shall not lead beyond excuse. At least it will be possible for the reader to follow each movement and exercise control. – It may be unnecessary to say, that apart from those regarding main features – most clearly visible on the curves –, all the suggestions offered are tentative, and cannot well be otherwise, due to the incomplete and in part haphazard sampling.

The fact that the ages have been established according to different methods has been taken into consideration, as will appear from the following, whereas the difference between K/Ar ages arising from the alternating use of "American" and "Russian" λ_e has been neglected; it would be of the order of magnitude 50 m. y. (Welin and Blomqvist l. c. p. 46). Recalculation using an average λ_e would, presumably, give curves (within our limits of error) identical with those presented.

Fig. 3, I represents, in the manner outlined above, the distribution (on the time scale) of recorded ages ("density of age records", number of "ages" per 100 m. y.), taking (upper dotted line) without discrimination all dates available, and (continuous line) those from the Laboratory for pre-Cambrian Geology in Leningrad along with all others marked with an asterisk by Neumann – for the sake of convenience we shall call them "recognized" ages (dates, determinations). The lower, dotted line (L) represents the Russian determinations, the broken line (N) other "recognized" ages. The dots in rows just below the base of the diagram are the single dates; upper row the "recognized" determinations, lower row the remaining ones, which are hereafter left completely out of the picture. – Obviously this diagram is based on data resulting from many different kinds of analysis.

Fig. 3, II is based solely on the K/Ar values plus the five Rb/Sr ages – the latter plotted on the lower side of the row of dots (ages) at the base of the diagram. – The Fen area values, like those of the Oslo area, are not plotted in the main diagram, but are shown as separate curves (F and O). (For the construction of the "Oslo curves" another four values achieved by other methods were used, apart from the three K/Ar values 259, 284 and 315 m. y.). – The bold, continuous line represents all K/Ar and Rb/Sr ages, ordinates being the sum of the ordinates of three component curves, namely p (continuous, thin line) for pegmatites, i (broken line) for igneous rocks and g (lower, dotted line) for gneisses.

In the first category (p) are included pegmatites and other assemblages within which may loosely be called the pneumatolytic-hydrothermal group. To this group – the overwhelming majority of it being pegmatites proper – are counted 395 m. y. (muscovite from pyrite ore, Bleikvassli, circle *20*, Ac) and 1080 m. y. (biotite from apatite mine, Ødegården, circle *12* Dab).

The igneous rocks (i) are mostly granites, and the gneisses (g) are often of granitic composition. Especially in pre-Cambrian areas it is, as is well known, not always easy to decide whether to call certain rocks gneisses or granites. In this paper "granite" is a rock of granitic composition – taken in a somewhat wide sense – being unfoliated or only very slightly foliated. Or, to put it another way, the name is used such, I believe, that most geologists, on seeing a hand specimen only, could think of no better word. In doubtful cases the designation gneiss was preferred. Besides granites there are very few pre-Cambrian igneous rocks represented – there are, though, a few gabbroic ones. Of post-pre-

Cambrian age there are the Fen area rocks, some Caledonian intrusives of different categories and a few Permian (Oslo) igneous rocks.

The diagrams III, IV, V, VI are intended to demonstrate what may be done about the many ages established by "other methods" – that is about whatever remains of the continuous line curve I after removing the K/Ar and Rb/Sr ages. Such ages are depicted as before by the continuous line of III, and they all belong to the pegmatite (p) category apart from a few Oslo igneous rock ages.

Whereas the diagrams I and II exhibit several common features – distinct maxima at ~ 900, ~ 600, ~ 400 and ~ 250 m. y. – the curve III gives a disturbing picture. The absolute minimum (anorogeny) of II at ~ 650 m. y. to ~ 700 m. y., which is so to speak needed for the formation of the sub-Cambrian peneplane has been replaced by a maximum. It appears, however, that this is mainly due to a great accumulation of Re/Os ages of pre-Cambrian minerals (the dotted line), which is thus contradictory to geological evidence. This curve of Re/Os ages very clearly confirms the statement of Neumann (l. c.) that the Re/Os ages are too low. Neumann further suggests that the half-life value used for Re, $T = 6,2 \times 10^{10}$ y., might advantageously be increased by about 20 per cent. We may perhaps say that this has been confirmed by recent laboratory determinations namely $T = 7,9 \times 10^{10}$ (Kocol l.c.) and $T = (1,2 \pm 0,4) \times 10^{11}$ (Wolf and Johnston l. c.). – Neumann states that 690 m. y. may be used as an average for the seven Re/Os ages which constitute the maximum in question. An addition of 20 per cent would make 830 m. y., and actually a relative maximum (of activity) is faintly suggested on the diagram II at that time. A similar treatment of the older Re/Os ages would give as results (numbers in parentheses): Kobbernuten 862 (1030) m. y., Tveit 882 (1060) m. y., Tuftan 962 (1160) m. y., Tarjeisberg 1570 (1880) m. y., Vatterfjord (see diagram I) 2290 (2750) m. y. – Neumann points tentatively at ~ 1100 m. y. as a possible age of events. Diagram II might suggest a relative maximum at a slightly lower age, not so much different from the improved Kobbernuten and Tveit ages; the improved Vatterfjord age matches with the Lewisian age (~ 2700 m. y.) of Giletti (see Neumann l. c.); the Tuftan age matches only the Nordby pegmatite age of 1148 – a lone swallow, one might object. To compare the Tarjeisberg age with the Eptevann pegmatite ages 1650 and 1750 m. y. might be unfair exploitation of possibly remaining goodwill with the reader. I still take the opportunity to recall the recent recording of the age of 1800 m. y. in Nordfjord (Cd) (McDougall and Green l. c.),

which locality is on the other hand nearly as far away as the nearest Swedish locality with a similar age.

Even though there may be some indications of their existence, the result of this search of pigeonholes for the improved Re/Os ages seems too meagre to justify the incorporation of them in the curves of II. They should be kept in mente for future accommodation, but at present it will be better to remove them from the picture, which thereby changes into that of diagram IV. – Table no. 2 shows that further cleaning up can be done. The Auselmyra and the Rømteland localities (shown by the dotted line of diagram IV) are strongly overrepresented. Of the Rømteland ages only that of 920 m. y., of the Auselmyra the average value (1085 m. y.) only, will be retained[3] (cp. the remarks of Neumann l. c.). The curve thereby changes its course into that of diagram V. – Further the Oslo area ages should be removed since they are already used for the diagram II, O, and likewise the ages 450 and 530 m. y. (Kalstad, circle *12*) and 610 m.y. (Tvedestrand, circle *13*)[4] which results in the curve VI. Even after this severe treatment (cp. curves III–VI) a pronounced maximum at ~ 900 m. y. remains. Only the following nine ages are left from the original lot (curve III) of ca. fifty: Auselmyra 1085 m. y. (average); Kalstad 980 and 940 m. y.; Rømteland, Kåbuland, Karlshus 920 m. y.; Kåbuland 884 m. y.; Frikstad 820 and 755 m. y. – Even out of these some might perhaps be sacrificed, but they are actually of negligible consequence here – can do very little harm, so to speak. If the nine remaining pegmatite ages were incorporated in diagram II, the result would be to stretch the curve of pegmatites (p) and correspondingly the "total" curve a little upwards (cp. the widely-spaced dotted lines).

The final diagram (II) is essentially based on K/Ar determinations. Two ages of major events seem to be manifest; one at ~ 900 m. y. and one at ~ 400 m. y. The former represents what Magnusson (1960) has

[3] It is admitted that these two localities would deserve to be represented by more than one "dot" each in the diagram – but by how many? As to the former, a greater weight would not mean so much in the present context since it would be a corollary to the firmly established maximum at ~ 900 m. y. – As regards Auselmyra it would lend more probability to the postulated age of events at ~ 1100 (Neumann).

[4] These two localities are within the very "stronghold" of South Norwegian pre-Cambrian, where such low ages would be difficult to account for without resorting to hypotheses such as rejuvenation in connection with the great South Norwegian faults, with Oslo, Fen or unknown volcanogenetic activity etc, etc.

defined as the "Sveconorwegian[5] Regeneration Period". The latter represents (the main phase of) the Caledonian folding, in good agreement with the 420 ± 15 m. y. Rb/Sr age of regional metamorphism within the Moine series of the Scottish Highlands (Giletti a. o., l.c.). For both the maxima in question there is good harmony in the diagram between the pegmatite (p), igneous (i) and gneiss (g) curves. Besides these probably undisputable ages of "orogeny" (time marking event) there is an equally distinct period of anorogeny at ~ 675 m. y. (725 to 625 m. y. ?), which might be a period of peneplanation – formation of the sub-Cambrian peneplane, – and the anorogeny after ~ 300 m. y. (~ 300 to 0 m. y.). Further we seem to have two similarly undisputable maxima due to volcanogeny (disruption): the Fen eruption at 580 m. y. and the Oslo activity at ~ 275 m. y. (310 to 240 m. y. ?).

Less convincing is the maximum at ~ 575 m. y. There are no igneous (i) ages here and the four recorded ages are from widely separated areas. 582 m. y. Loen (Cd) and 590 m. y. Ortnevik (Cc) are pegmatite ages from localities not too far from each other, within the "north-western gneiss area"; 575 m. y. Langøy (Aef) from augengneiss far in the north, but in position relative to the Caledonian folding zone perhaps not too different from that of the two mentioned above. 550 m. y. Fåberg (Dc), is estimated from shale from the Brøttum sparagmite. The value was determined by total rock age analysis. Polkanov (personal communication of 26th July 1960) remarks a. o.: "Thus the Brøttum sparagmite shows the true age of Caledonian metamorphism and not the age of sedimentation or diagenesis processes. . . . the rock has a subparallel Gefügeregelung of sericite – muscovite, has formed during petrotectonical Durchbewegung. – Thus both samples of sparagmites from Brøttum and from middle Sweden have the same age of Caledonian metamorphism 550 m. y. and 560 m. y. and the true age of sedimentation and diagenesis is unknown."

Neumann (l. c.) says of the micas with apparent ages of 582 m. y. and 590 m. y. (the other two values were unknown to him) that they "may be of Caledonian origin but are probably older. Argon . . expelled during . . Caledonian orogeny and metamorphism." He does not give his reasons for this opinion; before more data are available we should on principle neither disallow nor sanction. But I can't but point to the fact that something, leaving traces, seems to have happened, at least in "southern

[5] Would not "Swedonorwegian" or "Sveconorvegic" be preferable ?

Norway" at that time (Brøttum metamorphosis, Fen activity), and further that the apparent age of 575 m. y. (northern Norway) has been added. Polkanov and Gerling (1960), following Mayne, put 610–620 m. y. as the beginning of the Caledonian orogeny. If the ages in question really are Caledonian, then this orogeny, according to the scale of Kulp (l. c.) and Holmes (l. c.), would in Norway have covered the space of time from eo-Cambrium (fore-runners?) to upper Devonian (or even lower Carboniferous). – If, further, the minimum at ~ 525 m. y. does not mean just poor information (which is admittedly quite possible), there would have been another anorogenetic or pene-anorogenetic time – would that mean Cambrian? If so, the age of the Cambrian accords better with the value given by Polevaya (Н. И. Полевая 1961) than with the value of Holmes and Kulp.

Very few signs of ages greater than 1100 m. y. have been traced. The Lewisian (?) age of 2290 (2750?) m. y. has been touched upon above, and likewise the 1800 m. y. age; both outside the southern pre-Cambrian area. The Langsev age of 1345 m. y. may be the first of the much missed 1400 m. y. ages. But one must agree with Magnusson (l. c.) that so far it seems as if sveconorvegic events at ~900 m. y. have more or less obliterated "ages" greater than ~ 1100 m. y. in southern Norway. This may be the all-overshadowing phenomenon.

If this picture does not change with accumulating geochronological information – and such was actually the sinister, even if conversational prophecy of some of our geologists nearly ten years ago – then we shall in future be depending more or less exclusively on orthodox geological methods (or, of course, on methods still to be invented). I cannot see, by the way, that very much of what has been assumed by different geologists previously about the pre-Cambrian of southern Norway can be overruled by more or less effaced data unknown to them. Such data should logically (since effaced) not influence our present judgement very much either. I certainly am no advocate of the division into three or four "formations" (Neumann l. c., p. 188), though for quite different reasons.

The following reflections on possible events between ~ 1100 m. y. and ~ 700 m. y. I would like to introduce with a "valeat quantum valere potest". They are more or less based on the course of the curves of the diagram (II) and it may be questionable whether 66 determinations – on the average 16 per 100 m. y. – are sufficient to justify the procedure. – Neumann (l. c.) has tentatively postulated that besides major events between ~ 900 and ~ 950 m. y. there occurs one such period at ~ 1100

m. y. This is expressed to some extent in the diagram II, which thus at least does not contradict his statement, even if an age of ~ 1050 m. y. would fit better. But there is an equally strong indication at 850–800 m. y., (it might be shored up with Re/Os ages by those so inclined), and perhaps at ~ 975 m. y.

The pegmatite (p) curve with its maximum at 925 m. y. and its smooth course is a dominating feature in the picture. Why is it so much smoother than the igneous (i) and the gneiss (g) curve? The difference in representation seems not to be a sufficient explanation, since this difference is not very considerable (p = 27, i = 19, g = 20). It might seem, then, to be a stronger tendency towards even distribution of ages with the pegmatites than with the igneous and gneissic rocks. Is it true that there has been a sequence of granite producing events – say, for instance, at (~ 1050), ~ 975, ~ 900 and ~ 825 m. y. – representing separate orogenies or being culminations of activity within one long lasting orogeny? (cp. Magnusson l. c.). Consistent reasoning leads to the conclusion that a period of granitization esp. palingenesis would involve preceding, contemporaneous and succeeding pegmatite formation, which would, under the circumstances imagined above give possibilities for overlapping in time of the formation periods of pegmatites connected with granites of different ages.

After these vagaries it may be good once more to recall the scantiness of information, and perhaps even the possibility of mixed ages: old pre-Cambrian rejuvenated by the 900 m. y. and later events on the left hand flank of the big "milestone" of the diagram, Caledonian and other rejuvenation on the right hand slope. In this connection it may be taken into consideration that ages younger than 920 m. y. K/Ar time have not been reported from the pre-Cambrian of Sweden (Magnusson l. c.) but are abundant in Norway. This *might* be viewed in relation to the proximity of the Caledonian zone of folding, the great faults and the Fen and Oslo activities.

What seems to be established with some degree of probability, is that there were major periods of "orogeny" at ~ 900 m. y. (+) and ~ 400 m. y. mica K/Ar time; of volcanogeny at 580 and ~ 250 m. y.; of anorogeny at 675 m. y. ±, and from ~ 300 to 0 m. y. Further the possibility of orogeny at ~ 575 m. y. (with anorogeny at 500 m. y. ±) may be kept in mind along with the faint indications of possible events at ~ 2700, ~ 1800, (~ 1400), 1100 (– 1050) and 850 (– 800) m. y.

As might have been foreseen, the cursory analysis above has revealed that a considerable part of the available age determinations cannot for the time being serve as geological time markers. The present writer considers that only the ages used for the construction of the "final" diagram (II, fig. 3) – they are shown in the table 7 (below) and on the "final" map (fig. 4) – are possibly relevant to geochronology; and even among these some may of course be discarded when more information has been collected.

The original number of about 220 age determinations (about 160 "recognized" determinations) is thereby reduced to 125.* Nearly two thirds of these 125 determinations are from the Laboratory for pre-Cambrian Geology, Leningrad.

Table 7: revised list.

Age determinations, which, according to the discussion above may have bearing upon geochronology. Compare also diagram II, fig. 3, and map. fig. 4.*

(N = vide Neumann l. c., L = determination by the Laboratory for pre-Cambrian Geology, Leningrad, A, B. . . a, b. . .: position on the map fig. 4.)

a. K/Ar mica ages.

259 m.y. Biotite from porphyritic granite. Near Skoglyst, Drammen, Buskerud. Db. (H. Faul 1959). N.

284 m.y. Biotite from essexite porphyrite. Sande, Vestfold. Db. (S. S. Goldich). N.

315 m.y. Lepidomelane from nepheline syenite pegmatite. Langesundsfjord. Dab. Geological Museum, Oslo, ded. L.

346 m.y. Biotite from Caledonian granitic gneiss (same sample as 381, below). Foot of Barbrahei hill, about 4 km SSW of Kjerringøy church, Kjerringøy, Nordland. ABde. Chr. Dick Thorkildsen leg. 1960. L.

355 m.y. Biotite from hypersthene mica-diorite (rock described by V. M. Goldschmidt in "Geologisch-Petrographische Studien im Hochgebirge Norwegens". Videnskapsselskapet i Kristiania Skrifter 1916). The rock is probably of early Devonian age (Per Holmsen commun.). Orkla bridge, road 50, Ulsberg, Rennebu, Sør-Trøndelag. Dd. Per Holmsen leg. 1962. L.

367 m.y. Biotite from granite. Near Kroksviken about 4 km SW of Kjerringøy church, Kjerringøy, Nordland. ABde. Chr. Dick Thorkildsen leg. 1960. L.

367 m.y. Biotite from biotite gneiss (micaceous gneiss). Age unknown, possibly same as 370. Completely recrystallized during Caledonian orogeny (Per Holmsen commun.). Road 640 by Stekeren farm, Oppdal, Sør-Trøndelag. Dd. Per Holmsen leg. 1962. L.

370 m.y. Biotite from augengneiss. Supposed age pre-Cambrian or Silurian. Completely recrystallized during Caledonian orogeny (Per Holmsen commun.). Road 640 by Lønset, Horg, between Oppdal and Sunndal, Sør-Trøndelag. Dd. Per Holmsen leg 1962. L.

* See, however, "Addendum", p. 111.

381 m.y. Muscovite. Same rock sample as 346, above. (Kjerringøy). L.

385 m.y. Biotite from gneiss. Dalsnibba, Veøy, Møre og Romsdal. Cd. (J. L. Kulp 1960). N.

388 m.y. Biotite from biotite gneiss belonging to the basal gneiss complex. Most probably pre-Cambrian. Completely recrystallized during Caledonian orogeny (Per Holmsen commun.). Road 640 by Lønset between Oppdal and Sunndal, Horg, Sør-Trøndelag. Dd. Per Holmsen leg. 1962. L.

391 m.y. Biotite from gneiss. Slope of Mt. Låtetind, about 7 km NE of Kjerringøy church (i.e. about 10 km NE of 346 + 381 – not 5 km, cp. report, tables 5 and 6, above), Kjerringøy, Nordland. ABde. Chr. Dick Thorkildsen leg. 1960. L.

395 m.y. Muscovite from pyrite ore. Bleikvassli, Korgen, Nordland. Ac. (J. L. Kulp 1960). N.

405 m.y. Biotite from Caledonian porphyric granite of the Bindalen massif. Skorovass cable way, angle no. 2, Tverrådalen, Strompdalsheia, Namsskogan, Sør-Trøndelag. Ef. Chr. Oftedahl ded. 1958. N. L.

405 m.y. Biotite from gneiss. Geiranger, Sunnylven, Møre og Romsdal. Cd. (J. L. Kulp. 1960). N.

413 m.y. Muscovite from pegmatitic rock within the "gneiss area west of Bergen". Telavåg, Sund (on Sotra), Hordaland Bbc. Geological Museum, Bergen ded. 1958. L.

423 m.y. Biotite from pegmatite. Røshagen at Selvågfjord, Bø, Langøy, Vesterålen, Nordland. Aef. (J. L. Kulp. 1960). N.

425 m.y. Muscovite from pegmatite. Kvamsvåg, Alversund, Hordaland. Bc. (J. L. Kulp 1960). N.

430 m.y. Biotite from grey gneiss. Jægtbøgen, Sortland, Langøy, Vesterålen, Nordland. Aef. (J. L. Kulp 1960). N.

434 m.y. Biotite from pegmatite within the "gneiss area west of Bergen". Tveit, Sund (on Sotra), Hordaland. Bbc. Geological Museum, Bergen ded. 1958. N. L.

450 m.y. Biotite from mica schist. Storelva between Viksfjord and Gåsfjord, Sortland, Langøy, Vesterålen. Aef. (J. L. Kulp 1960). N.

450 m.y. Muscovite from pegmatite. Gneiss area west of Bergen. Liavann, Laksevåg, Hordaland. Bbc. Geological Museum, Bergen ded. 1958. N. L.

550 m.y. Shale from Brøttum Sparagmite. West side of river Lågen by bridge at Fåberg, Oppland. Dc. Steinar Skjeseth leg. L.

565 m.y. Biotite from carbonatite, cp. 568, 573, 585, 590, 603. Søve mine, Fen, Holla, Telemark. Db. (Henry Faul 1959). N.

568 m.y. Biotite from Søvite, cp. 565. Fen, Holla, Telemark. Db. Tor Siggerud ded. 1959. L.

573 m.y. Biotite from damtjernite, cp. 565. Fen, Holla, Telemark. Db. S. Bergstøl leg. 1959. L.

575 m.y. Biotite from augengneis. Crossroads between Sandnes and Sandnesodden, Sortland, Langøy, Vesterålen. Aef. (J. L. Kulp 1960). N.

582 m.y. Muscovite from pegmatite, north-western gneiss area. Loen, Stryn, Nordfjord, Sogn og Fjordane. Cd. Geological Museum, Bergen ded. 1958. N. L.

585 m.y. Biotite from kimberleyite, cp. 565. 1 km south-west of the Fen area; by Steinsrud, Holla, Telemark. Db. (J. L. Kulp 1960). N.

590 m.y. Biotite from søvite, cp. 565. Fen, Holla, Telemark. Db. Sverre Svinndal ded. 1958. N. L.

590 m.y. Muscovite from pegmatite; north-western gneiss area. Ortnevik, Kyrkjebø, Sogn og Fjordane. Cc. Geological Museum, Bergen ded. 1958. N. L.

603 m.y. Biotite from søvite, cp. 565. Fen. Same sample as 590 above.

758 m.y. Biotite from pegmatite. Araodden, Totakvann, Rauland, Telemark. Cb. Olaf Anton Broch leg. 1958. L.

759 m.y. Biotite from gneiss, east of Egersund formation. Remesvik, Lindesnes (formerly Sør-Audnedal), Vest-Agder. Ca. (W. Kley and P. Schmidlin). N.

772 m.y. Biotite from nearly unfoliated Telemark-granite, obviously younger than

surrounding Telemark (granitic) gneiss. Possibly palingenetic. Araodden, Totakvann, Rauland, Telemark. Cb. Olaf Anton Broch leg. 1958. N. L.

776 m.y. Biotite from granite (Østfold granite), cp. 802, 823, 839. Onsøy, Østfold. DEb. Olaf Anton Broch leg. 1958. N. L.

802 m.y. Biotite from granite (Østfold granite), same sample as 823 below, cp. 776. Near Solli church, Tune, Østfold. DEb. Olaf Anton Broch leg. 1958. N. L.

815 m.y. Biotite from "Telemark granite". Sandå, S. Sundsli, Åmli, Aust-Agder. CDa(b). (J. L. Kulp 1960). N.

815 m.y. Biotite from norite. About 200 m SW of 864 (Ualand) below. Chr. Dick Thorkildsen leg. 1959. L.

823 m.y. Biotite from granite, cp. 776. Near Solli church, Østfold. Same sample as 802 above. N. L.

824 m.y. Biotite from granite gneiss (Telemark "granite"); somewhat foliated; uniform within a wide area. (Same rock as 857 and 868 (below), which were collected 1,5 km farther east). Road Gol–Ål; 3,25 km W of crossroads (Oslo/Borlaug/Geilo), Gol, Hallingdal, Buskerud. Dc. Olaf Anton Broch leg. 1958. N. L.

825 m.y. Biotite from farsundite. Rømteland (Rymteland), Lindesnes (formerly Sør-Audnedal), Vest-Agder. Ca. (J. L. Kulp 1960). N.

828 m.y. Biotite from pegmatite (same sample as 836 below). Bruna by Rorevann near Grimstad, Landvik, Aust-Agder. CDa. Olaf Anton Broch leg. 1958. L.

836 m.y. Biotite from pegmatite. Bruna (same sample as 828 above). L.

839 m.y. Biotite from "Østfold granite", cp. 776. Iddefjord, Idd, Østfold. DEb. (J. L. Kulp 1960). N.

842 m.y. Biotite from small pegmatite body in Telemark gneiss (granite gneiss). 1–2 km south of the old church, at new road along southern shore of lake Kviteseid, Telemark. CDb. Olaf Anton Broch leg. 1958. N. L.

850 m.y. Biotite from granite. Fevik, Fjære, Aust-Agder. Da. (J. L. Kulp 1960). N.

850 m.y. Biotite from granite. Amtmannsvingen, Tvedestrand, Aust-Agder. Da. (J. L. Kulp 1960). N.

852 m.y. Biotite from pegmatite. Bjertnes feldspar quarry, Krødsherad, Buskerud. Dbc., cp. 895, 977 below, and "Remarks" on 1640, 1690. N. L.

857 m.y. Biotite from granitic gneiss (cp. 824 above). Same sample as 868 below. Nearly 2 km W of cross roads (Oslo/Borlaug/Geilo), Gol in Hallingdal, Buskerud. Dc. N. L.

860 m.y. Muscovite from pegmatite. Iveland, Aust-Agder. Ca. (J. L. Kulp 1960). N.

860 m.y. Biotite from granite. ("Herefoss granite"). Landvik, Aust-Agder. CDa., cp. 930 below. (J. L. Kulp 1960). N.

861 m.y. Biotite from pegmatite, same locality as 905 below. Åmli feldspar quarry, Herefoss, Aust-Agder. CDa. Olaf Anton Broch leg. 1958. L.

864 m.y. Biotite from norite, Egersund area; cp. 815 above. Ca. Road no. 440, 2 km S of Ualand railway station, Heskestad, Rogaland. Chr. Dick Thorkildsen leg. 1959. L.

868 m.y. Biotite. Gol, same sample as 857 above. N. L.

870 m.y. Biotite from gneiss. Flaten, Åmli, Aust-Agder. Da. (J. L. Kulp 1960). N.

874 m.y. Biotite from pegmatite. Road Vik (near Grimstad)–Froland, 50 m. N of the small farm Langemyr, 3 km N of cross roads Rykene (Arendal/Grimstad/Løddesøl) (near 1030 below), Øyestad, Aust-Agder. CDa. Olaf Anton Broch leg. 1958. N. L.

880 m.y. Biotite from pegmatite. Small "temporary" feldspar quarry in road under repair. 100 m N of farm Håvardstad, Iveland, Aust-Agder. Ca. N. L.

890 m.y. Biotite from "Dagali gneiss", probably a metamorphic Telemark porphyry. Near the dairy at Ål railway station, Ål, Buskerud. CDc. Olaf Anton Broch leg. 1958. N. L.

895 m.y. Sericite from pegmatite. Bjertnes feldspar quarry, Krødsherad, Buskerud, cp. 852 above. (J. L. Kulp 1960). N.

900 m.y. Biotite from "banded Kongsberg-Bamle gneiss" (Arne Bugge l.c.). Cross-

roads "Omre" (Grimstad/Lillesand/Homborsund), Landvik (Eide), Aust-Agder. CDa. Olaf Anton Broch leg. 1958. N. L.

904 m.y. Muscovite from pegmatite; Haugesund peninsula. Tor's mine, Vats, Ryfylke, Rogaland. BCb. Geological Museum, Bergen ded. 1958. N. L.

904 m.y. Biotite from pegmatite, cp. 970 below. Løvrak (Lauvrak) feldspar quarry, Froland, Aust-Agder. CDa. Olaf Anton Broch leg. 1958. N. L.

905 m.y. Muscovite from pegmatite (same locality as 861 above). Åmli feldspar quarry, Herefoss, Aust-Agder. CDa. Olaf Anton Broch leg. 1958. N. L.

915 m.y. Biotite from pegmatite. Tarjeisberg, Kviteseid, Telemark. C(D)b. (J. L. Kulp 1960). N.

924 m.y. Biotite from gneiss (same sample as 936 below). Øyerberget, Brandval, Hedmark. Ebc. Chr. Dick Thorkildsen leg. 1960. L.

925 m.y. Biotite from mica schist. NNE of Flaten, Åmli, Aust-Agder. Da. (J. L. Kulp 1960). N.

927 m.y. Biotite from pegmatite perhaps connected with the "Herefoss granite" (860, 930, 956, 975); same sample as 930 below, and 966 (Rb/Sr determination) below. Grøsle feldspar quarry, Landvik, road 387 Skiftenes – s. Herefoss, Aust-Agder. CDa. Olaf Anton Broch leg. 1958. N. L.

927 m.y. Biotite from granite ("Flå granite"), cp. 943, 950, 952. Tunnel near Gulsvik railway station, Flå, Buskerud. Dbc. Olaf Anton Broch leg. 1958. N. L.

929 m.y. Biotite from gneiss. Heller farm, Askim, Østfold. DEb. (W. Kley and P. Schmidlin). N.

930 m.y. Biotite from granite ("Herefoss granite"), cp. 860, 956, 975. Killandsvann, Landvik, road 387 Skiftenes – s. Herefoss, Aust-Agder. CDa. Olaf Anton Broch leg. 1958. N. L.

930 m.y. Biotite from pegmatite, same sample as 927 above. Grøsle feldspar quarry. CDa. N. L.

935 m.y. Biotite from pegmatite. Feldspar quarry Hella no. 3, Tromøysund, Stokken, Aust-Agder. Da. (J. L. Kulp 1960). N.

936 m.y. Biotite, same sample as 924. Øyerberget. Ebc. L.

940 m.y. Biotite from gneiss. Assevvann, Øyestad, Aust-Agder. Da. (J. L. Kulp 1960). N.

943 m.y. Biotite from granite ("Flå granite"), cp. 927 above. Ospeholt, Hedal, Sør-Aurdal, Oppland. Dc. Olaf Anton Broch leg. 1958. N. L.

946 m.y. Muscovite from pegmatite; same sample as 1030 (Rb/Sr age) below; cp. also 1148. Nordby feldspar quarry, Rakkestad, Østfold. Eb. Olaf Anton Broch leg. 1958. N. L.

950 m.y. Biotite from granite ("Flå granite"), cp. 927 above. WNW of Hedal church, Hedal, Sør-Aurdal, Oppland. Dc. (J. L. Kulp 1960). N.

952 m.y. Biotite from granite ("Flå granite"), cp. 927 above. Road cut at Gryte, 6 km S. of Viker church, west side of lake Sperillen, Ådal, Buskerud. D(b)c. Olaf Anton Broch leg. 1960. N. L.

956 m.y. Biotite from granite ("Herefoss granite"), cp. 930 above. Near Grøsle feldspar quarry, cp. 927 above. CDa. Olaf Anton Broch leg. 1958. N. L.

965 m.y. Biotite from granite ("Tinn granite"). North of lake Tinnsjø, Tinn, Telemark. Db. (J. L. Kulp 1960). N.

965 m.y. Muscovite from pegmatite. Hyttåsen, Hobøl, Østfold. DEb. (W. Gentner and W. Kley 1957). N.

970 m.y. Muscovite from pegmatite. Løvrak feldspar quarry, same locality as 904 above. CDa. Olaf Anton Broch leg. 1960. N. L.

975 m.y. Biotite from granite ("Herefoss granite"), cp. 930; west of the great fault (Arne Bugge l.c.) – 930, 860, 956 are from the east side. Senomstad bridge, south of s. Herefoss (Åmli), Herefoss, Aust-Agder. C(D)a. Olaf Anton Broch leg. 1960. N. L.

977 m.y. Muscovite from pegmatite, cp. 852 above. Bjertnes feldspar quarry, Krødsherad, Buskerud. Dbc. Olaf Anton Broch leg. 1958. N. L.

990 m.y. Biotite from veined gneiss belonging to the "Telemark area" west of the great fault (Arne Bugge l.c.). Vein material looks as if coming from, or con-

nected with the formation of, the "Flå granite", cp. 927 etc. East side of lake Krøderen, road 20, nearly 2 km. W of cross roads "Hamremoen" (Hønefoss/Vikersund/Gol), Krødsherad, Buskerud. Db(c). Olaf Anton Broch leg. 1958. N. L.

990 m.y. Biotite from migmatic gneiss. Between n. Herefoss and Hanefoss, Herefoss, Aust-Agder. C(D)a. Olaf Anton Broch leg. 1960. N. L.

1007 m.y. Biotite from gneiss, same sample as 990 above. Herefoss.

1010 m.y. Biotite from arendalite, cp. 1040 below. Hisøy, Aust-Agder. Da. (J. L. Kulp 1960). N.

1016 m.y. Biotite from gneiss. Valebø, Holla, Telemark. Db. Sverre Svinndal ded. 1958. N. L.

1030 m.y. Biotite from coarse grained granite (pegmatite?). Near 874 above; 3 km. north of cross roads "Rykene", Øyestad, Aust-Agder. CDa. Olaf Anton Broch leg. 1958. N. L.

1040 m.y. Biotite from arendalite, cp. 1345 below, and 1010 above. Langsev, near Arendal, Aust-Agder. Da. (S. S. Goldich). N.

1041 m.y. Phlogopite from pegmatite. Snarum, Modum, Buskerud. Db(c). (W. Kley and P. Schmidlin). N.

1048 m.y. Biotite from gneiss with abundant mica, "Kongsberg–Bamble banded gneiss", east of the great fault (Arne Bugge l.c.). Road 20, between Veme and Sokna, nearly 5 km. west of level crossing at Oppen; Heradsbygd, Norderhov, Buskerud. Dbc. Olaf Anton Broch leg. 1958. N. L.

1052 m.y. Muscovite from same rock sample as biotite 1048 above (between Veme and Sokna). N. L.

1055 m.y. Muscovite from pegmatite. 650 m. WNW of W of Spone church, Modum, Buskerud. Db. (J. L. Kulp 1960). N.

1080 m.y. Biotite from productive vein, apatite mine. Ødegården Verk, Bamble, Telemark. Dab. (J. L. Kulp 1960). N.

1105 m.y. Biotite from banded gneiss. Hisøy, Aust-Agder. Da. (J. L. Kulp 1960). N.

1105 m.y. Biotite from gneiss. Skarerveien, Lørenskog near Oslo, Akershus. D(E)b. N.

1148 m.y. Biotite from pegmatite, same locality as 946 above and as (Rb/Sr age) 1030 below. Nordby feldspar quarry, Rakkestad, Østfold. (D)Eb. Olaf Anton Broch leg. 1958. L.

1261 m.y. Biotite from pegmatite, cp. remarks above. Bruvollen, Hesnes, Fjære, Aust-Agder. CDa. L.

1345 m.y. Biotite from arendalite, cp. 1040 above. Langsev near Arendal, Aust-Agder. Da. (J. L. Kulp 1960). N.

1650 m.y. Biotite from pegmatite. Eptevann, Iveland, Aust-Agder. Ca. Olaf Anton Broch leg. 1958. L.

1750 m.y. Biotite, same sample as 1650 above.

b. Rb/Sr ages.

880 m.y. Lepidolite from pegmatite. Tørdal, Drangedal, Telemark. (C)D(a)b. (J. L. Kulp). N.

900 m.y. Lepidolite from pegmatite. Tørdal, Drangedal, Telemark. (C)D(a)b. (S. R. Taylor). N.

950 m.y. Microcline from pegmatite. Tørdal, Drangedal, Telemark. (C)D(a)b. (J. L. Kulp). N.

966 m.y. Biotite from pegmatite, same sample as 927 and 930 (K/Ar determinations). Grøsle feldspar quarry. N. L.

1030 m.y. Muscovite from pegmatite; same sample as 946 (K/Ar) above. Nordby, Rakkestad. L.

c. "Other" ages.*

216 m.y. Th^{232}/Pb^{208}. Zircon from Oslo nordmarkite. Trondheimsveien, large new road cut near Oslo city limit. Db. (H. Faul 1959). N.

* See, however, "Addendum", p. 111.

243 m.y. U^{238}/Pb^{206}. Thorite. Brevig. Dab. (A. O. Nier 1939). N.
259 m.y. U^{238}/Pb^{206}. Zircon from Oslo nordmarkite. Trondheimsveien, large new road cut near Oslo city limit. Db. (H. Faul 1959). N.
355 m.y. Th^{232}/Pb^{208}. Thorite. Brevig. Db. (A. O. Nier 1939). N.
755 m.y. RaD/Pb. Gadolinite from pegmatite. Frikstad, Iveland, Aust-Agder. Ca. (W. Herr, E. Merz, P. Eberhardt, P. Signer 1958). N.
820 m.y. Pb^{207}/Pb^{206}. Gadolinite from pegmatite. Frikstad, Iveland, Aust-Agder. Ca. (W. Herr, E. Merz 1958). N.
884 m.y. RaD/Pb. Blomstrandine from pegmatite. Kåbuland, Iveland, Aust-Agder. Ca. (W. Herr, E. Merz). N.
920 m.y. Pb^{207}/Pb^{206}. Uraninite from pegmatite. Rymteland, Lindesnes, Vest-Agder. Ca. (J. L. Kulp, W. R. Eckelmann 1957). N.
920 m.y. Th^{232}/Pb^{208}. Euxenite from pegmatite. Rymteland, Lindesnes, Vest-Agder. Ca. (J. L. Kulp, W. R. Eckelmann 1957). N.
920 m.y. Pb^{207}/Pb^{206}. Uraninite from pegmatite. Rymteland, Lindesnes, Vest-Agder. Ca. (S. Moorbath). N.
920 m.y. Pb^{207}/Pb^{206}. Blomstrandine from pegmatite. Kåbuland, Iveland, Aust-Agder. Ca. (W. Herr, E. Merz 1958). N.
920 m.y. Pb^{207}/Pb^{206}. Uraninite from pegmatite. Karlshus, Råde, Østfold. DEb. (S. Moorbath). N.
940 m.y. Pb^{207}/Pb^{206}. Euxenite from pegmatite. Kalstad, Kragerø, Telemark. (J. L. Kulp, W. R. Eckelmann 1957). N.
980 m.y. Th^{232}/Pb^{208}. Euxenite from pegmatite. Kalstad, Kragerø, Telemark. Dab. (J. L. Kulp, W. R. Eckelmann 1957). N.
1085 m.y. Average of the following 6 determinations of cleveite from Auselmyra, Tvedestrand (formerly Holt), Aust-Agder. Da. (1060 m.y. U^{238}/Pb^{206}., 1070 m.y. U^{235}/Pb^{207}., S. Moorbath 1960). (1090 m.y. Pb^{207}/Pb^{206}., 1110 m.y. Th^{232}/Pb^{208}., S. Moorbath). (1085 m.y. U^{238}/Pb^{206}., 1090 m.y. Pb^{207}/Pb^{206}., A. O. Nier). N.
? 2750 m.y. Tentative recalculation by the present author of 2290 m.y. (N.), see remarks above (comments on curve III): Re/Os determination (W. Herr and E. Merz 1958) of molybdenite from Vatterfjord, Vågan, Lofoten, Nordland. Aef.

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Janet Peacey, Fred Broadhurst and Terence Westall have endeavoured to remould my manuscript text into acceptable English.

Addendum.

When this manuscript was already at the printers I received a paper "Anzeichen einer frühkaledonischen Metamorphose" by Ivar Hernes. (N. Jb. Miner. Mh. 1964, 110–116). The author among other things discusses certain aspects of early Caledonian orogeny in some detail, and arrives at conclusions which do not conflict very much with what has been touched upon in the present paper.

To avoid confusion I should like to take this opportunity to correct an inadvertence. Mr. Hernes (l. c. p. 112 and 114) did not receive the unpublished Russian information referred to from the "Laboratory for pre-Cambrian Geology" but from the Geological Survey of Norway (Norges geologiske undersøkelse). Thus he employs the very same determinations and informations which have been used above.

* * *

By accident the important results of Moorbath and Vokes were not included in the compilation and discussion above. (Moorbath, S. and Vokes, F. M. Lead isotope abundance studies on galena occurrences in Norway. Norsk geologisk tidsskrift 43, pp. 283–343. Oslo 1963). The paper includes a map and a list of 37 model ages. 15 ages are negative and 5 do not fit the general picture shown in fig. 3, II, above. I am following the authors (l. c., p. 302) when I reject these 20 values as geological time markers. The remaining 17 determinations – 11 from northern Norway – fit the picture very well and should be added to table 2, to the section "other" ages of table 7 and to the uppermost, dotted line of fig. 3, II. The existence of peaks at about 900 m. y. and 400 m. y. is confirmed and so is the age of the Oslo activity; cp. fig. 5, p. 112, below.

The model age from Ettedalsgrubene, Vegårdshei, Aust-Agder of 1510 m. y., is interesting, since it adds to the few examples of ages above ca. 1100 m. y. For reasons given above (p. 101, on Re/Os ages) I cannot, however, look upon the Tarjeisberg age of 1560 m. y. as a corollary to the authors' tentative postulation of orogeny at 1500–1600 m. y. (l. c., p. 296); but we are, certainly, all aware that it is early days for entering into details.

The following lead isotope model ages determined on galena should, accordingly, be added to table 7, "other" ages, p. 109–110, above:

(**230** m. y. Kirkerøstene, Rostadfjell, Nordland. A(B)c(d)). **240** m. y. Mutta. Grua. Db(c). **250** m. y. Krækkjeheia, Hardangervidda. Cc(b). **260** m. y. Skjærpemyr, Grua. Db(c). **360** m. y. Mofjell mine, Mo-i-Rana, Nordland. A(B)d(c). **390** m. y. Jakobsbakken, Sulitjelma. Bd. **400** m. y. Bjørkåsen, Ballangen. Be. **420** m. y. Ravnåsen, Nordland. Ac. **420** m. y. Lille Tromsdal, Grong, Nord-Trøndelag. Ef. **420** m. y. Mosbergvik, Balsfjord, Troms. B(C) f. **470** m. y. Gurrogaisa, Finnmark. Dg. **730** m. y. Villdalsfjell, Bogen, Ofoten. Be. **760** m. y. Niingen, Bogen, Ofoten. Be. **830** m. y. Djupvik, Ofoten. Be. **920** m. y. Nordre Bygstøl, Kviteseid, Telemark. C(D) b. **930** m. y. Jakobselven, Sørvaranger, Finnmark. Eg. **1510** m. y. Ettedalsgrubene, Vegårdsheia, Aust-Agder. Da.

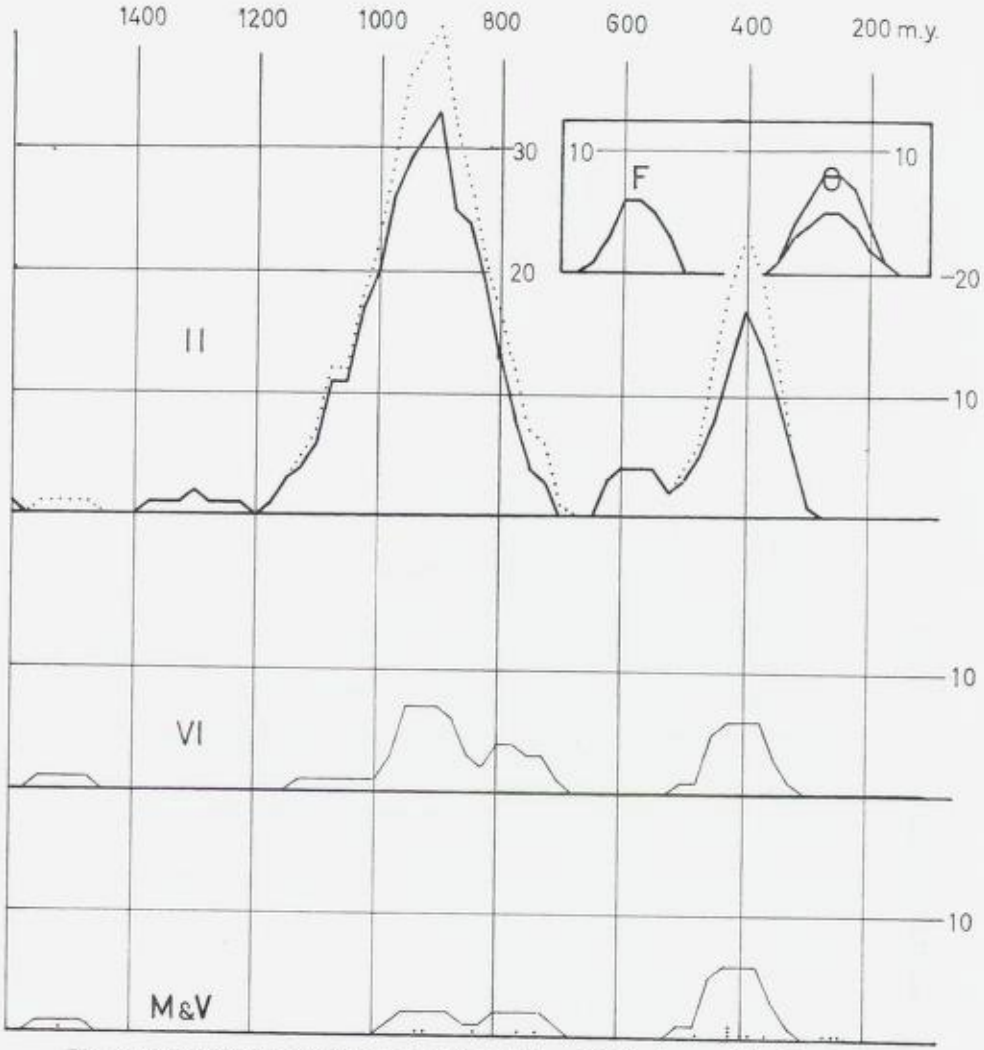

Fig. 5. Bottom: Age determinations by Moorbath and Vokes (see p. 111, above) plotted after the method used for fig. 3. – VI: "other" age determinations (cp. VI, fig. 3) including the determinations of Moorbath and Vokes. – II: Course of the widely spaced dotted line and the "Oslo curve" (II, fig. 3) when adding the determinations of Moorbath and Vokes. The curve of K/Ar and Rb/Sr ages is copied from II, fig. 3.

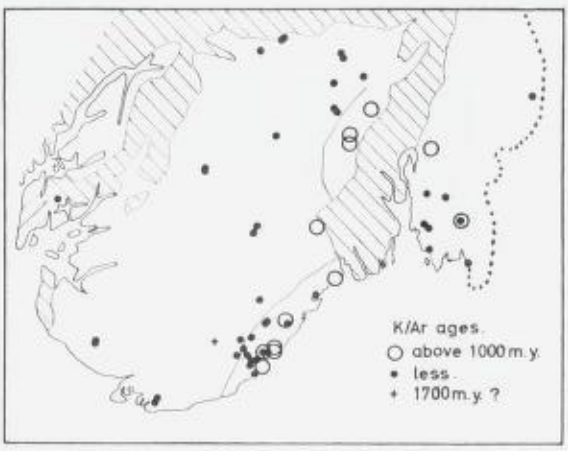

Fig. 1, see p. 98.

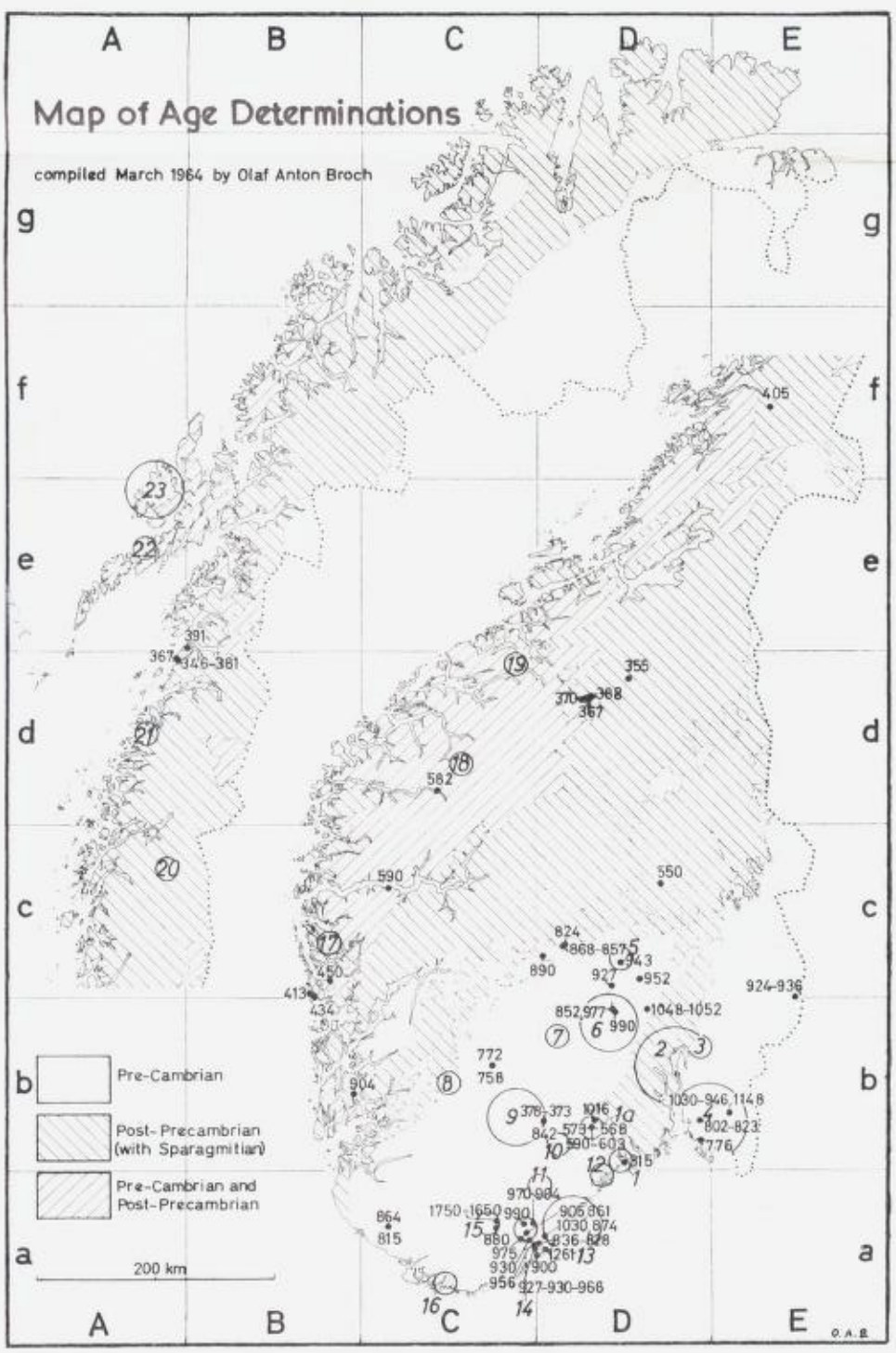

Fig. 2, see tables 1 and 2.

DISTRIBUTION ON TIME SCALE OF ESTABLISHED AGES. NUMBER OF DETERMINATIONS PER 100 M.Y.

I
II
III
IV
V
VI

Dots in rows
construction

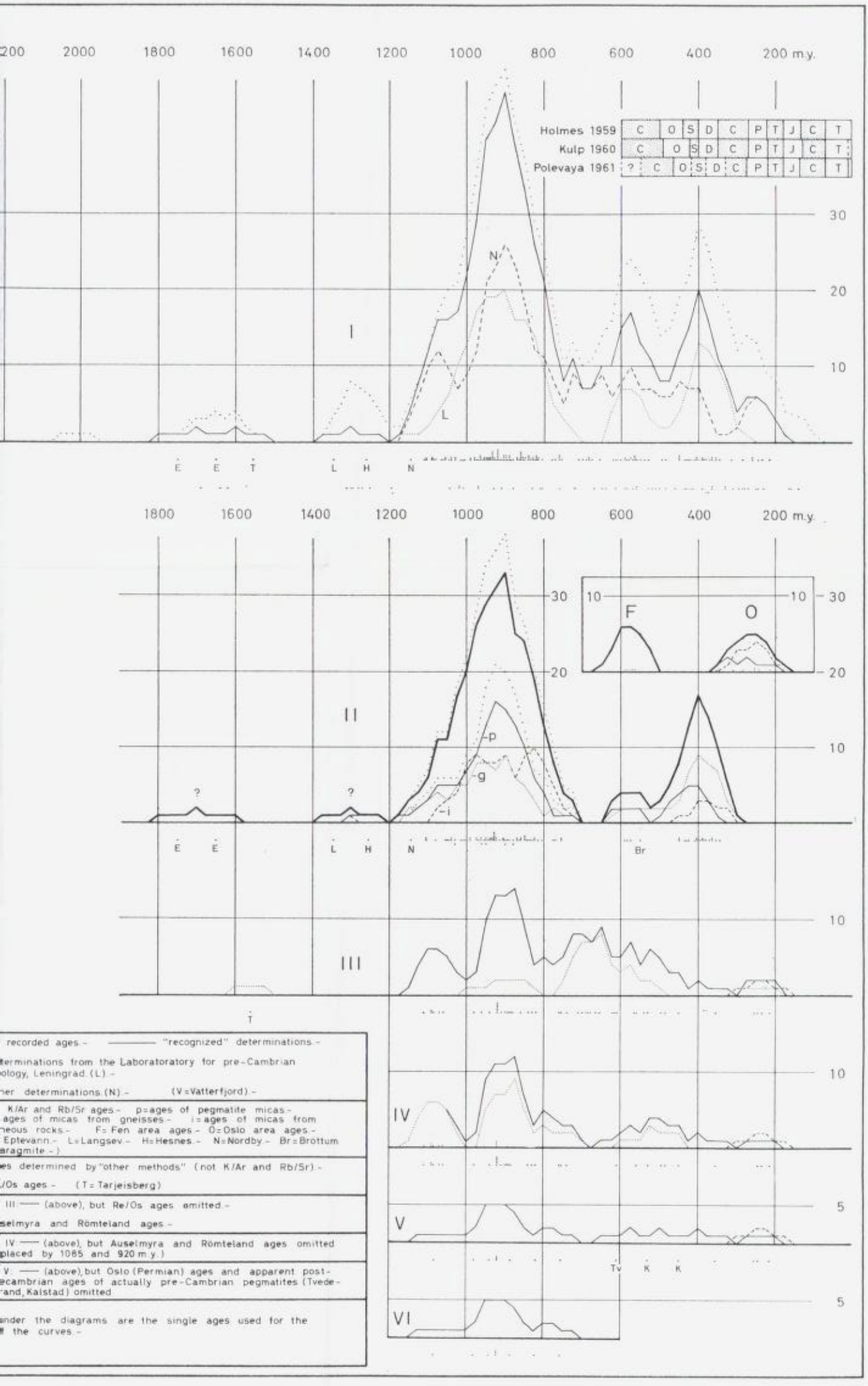

Fig. 3, see "Remarks", pp. 98–105.

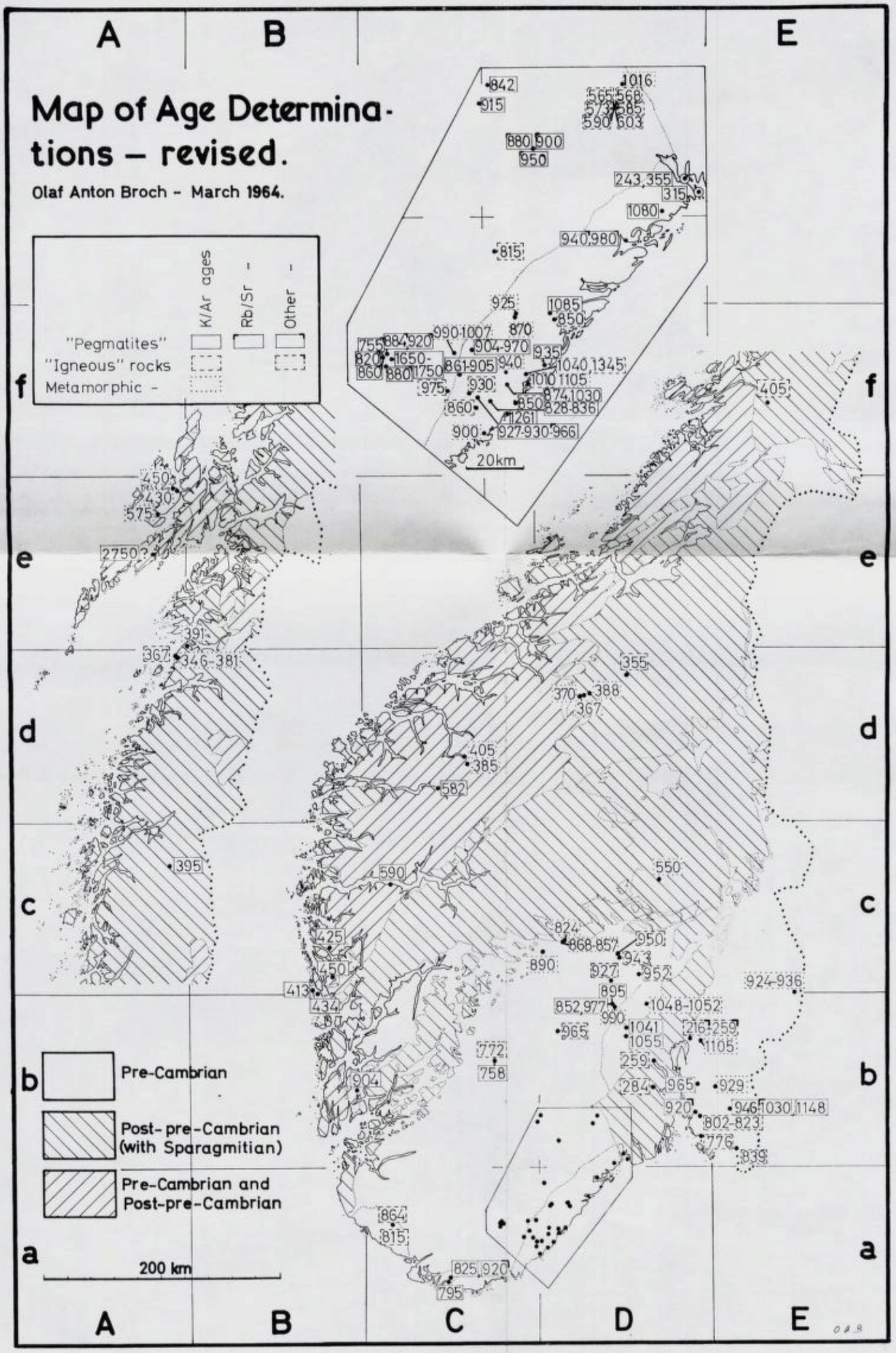

Fig. 4, see table 7.

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