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EGZOTYKI W OSADACH PELAGICZNYCH BATONU SERII NIEDZICKIEJ PASA SKAŁKOWEGO POLSKI

(Tabl. VIII—X i 5 fig.)

Fragments of Exotic Rocks in the Pelagic Deposits of the Bathonian of the Niedzica Series

(Pieniny Klippen-Belt, Carpathians)

(Pl. VIII—X and 5 fig.)

STRESZCZENIE

W batońskiej części wapienia bulastego dolnego serii niedzickiej w Czajakowej Skale na południe od Jaworek koło Szczawnicy znaleziono 32 egzotyczne fragmenty skał magmowych (porfiry kwarcowe mikrogranitowe, mikropegmatytowe, granofirowe i felzytowe — wszystkie komagmatyczne, tuf porfirowy i aplit), metamorficznych (granitognejsy dwumikowe i biotytowe, gnejsy muskowitowe, gnejsy oczkowe biotytowe) i osadowych (wapień). Fragmenty te są nieregularnie rozrzucone na eliptycznej powierzchni około 2 m^2, równoległej do warstwowania. Po obróceniu do położenia poziomego dłuższa oś tej elipsy przebiega NW-SE. Niektóre fragmenty tkwią w skale ukośnie w stosunku do powierzchni warstwowania, inne zaś równolegle. Duże fragmenty zagłębiły się w osadzie nieco bardziej niż małe. Te ostatnie prawdopodobnie wskazują powierzchnię dna w chwili depozycji fragmentów. Stosunek fragmentów skał egzotycznych do konkrecji wapienia bulastego jest przypadkowy. Wydaje się więc, że wapień bulasty był częściowo zdiagenezowany w chwili ich depozycji. Wielkość fragmentów waha się od 0,5 cm do 45,0 cm, ciężar wszystkich fragmentów wynosi 65,7 kg.

Dla poszczególnych fragmentów zostały określone: współczynniki Zingga $\left(\frac{b}{a} \; i \; \frac{c}{b}\right)$, kulistość (według „praktycznego wzoru" Waddela), stopień obtoczenia (według skali Pettijohna) i współczynnik A. Cailleux $\left(\frac{a+b}{2c}\right)$. Z analizy tych wartości wydaje się, że kształt

fragmentów jest bardziej zbliżony do kształtu otoczaków rzecznych niż plażowych morskich.

Wapień bulasty dolny serii niedzickiej był niewątpliwie osadem pelagicznym i batialnym lub nawet abyssalnym. Wydaje się, że najprawdopodobniejszym sposobem transportu fragmentów egzotycznych skał znalezionych w Czajakowej Skale z lądu w strefę sedymentacji wapienia bulastego dolnego był transport w korzeniach dryfującego drzewa lub przez „wyspę pływającą", wyrwaną przez powódź i zniesioną przez rzekę do morza. W każdym razie trzeba wykluczyć wyrzucenie fragmentów przez wybuch wulkanu, transport przez prąd zawiesinowy, przez górę lodową, przez zwierzęta (jako gastrolity) i przez glony wyrwane z dna.

Małe fragmenty egzotyczne występują sporadycznie i pojedynczo także w innych wapieniach bulastych, w radiolarytach i w biancone pienińskiego pasa skałkowego. Skały zawierające je są również pelagiczne i batialne lub abyssalne. Fragmenty egzotyczne mogły zatem być przetransportowane przez dryfujące drzewa lub przez „wyspy pływające" albo też przez glony wyrwane z dna.

Jeżeli się założy, że wszystkie fragmenty egzotyczne znalezione w Czajakowej Skale pochodziły z tego samego lądu, to można się starać zrekonstruować z nich najprostszą możliwą budowę geologiczną. Byłaby ona następująca: masyw krystaliczny (granitognejsy i gnejsy) intrudowany w dolnej części aplitami, w górnej porfirami, przykryty produktami wybuchów kwaśnych wulkanów (porfiry felzytowe i tuf porfirowy) i skałami osadowymi (wapień prawdopodobnie triasowy). Jeżeli się założy, że ląd, o którym mowa, znajdował się w geosynklinie karpackiej (na co istnieje wiele danych dyskutowanych w pracy), można by przez analogię ze znanymi profilami stratygraficznymi starszego kompleksu skalnego Karpat określić wiek masywu krystalicznego jako przedgórnokarboński, intruzji i ekstruzji — jako górny karbon-perm, tej zaś części osłony osadowej, którą reprezentuje wapień — jako środkowy trias.

Z masywów krystalicznych w geosynklinie karpackiej nie mogły dostarczyć egzotyków do Czajakowej Skały: krystalinikum tatrzańskie i masyw egzotykowy między basenami pienińskiego pasa skałkowego a serii wierchowej sensu lato (ze względu na charakter petrograficzny skał magmowych), masyw między basenami serii niedzickiej i braniskiej (ponieważ nie był w batonie wynurzony). Natomiast mogły dostarczyć tych egzotyków masywy krystaliczne Karpat zewnętrznych. Skład petrograficzny najbardziej południowego z nich, to znaczy masywu między basenem serii czorsztyńskiej a bruzdą czetechowicką i jej wschodnim przedłużeniem, jest uderzająco podobny do składu opisanych w tej pracy egzotyków. Ponadto masyw ten był w batonie najbliższym basenu serii niedzickiej lądem.

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Abstract. Some exotic fragments of igneous, metamorphic and sedimentary rocks occur in the Bathonian of the Niedzica Series, Pieniny Klippen-Belt of Poland. The shape of the fragments suggests alluvial gravel. The fragments are enclosed in the pelagic and bathyal nodular limestone. Their deposition was undoubtedly simultaneous with that of the enclosing rock. The mode of transportation of these exotic fragments is discussed, and it is suggested that transportation by driftwood or by a „floating island" of tangled growth is the most probable. An attempt is made to reconstruct the stratigraphic sequence in the land the exotic fragments derived from, and to determine the position of this land in the Carpathian geosyncline.

A. GEOLOGICAL PART

by K. Birkenmajer and S. M. Gąsiorowski

The Niedzica Series has been formed along the northern border of the central part of the Pieniny Klippen-Belt sedimentary basin. The primitive position of the Niedzica Series was between the sedimentary regions of the Czorsztyn Series to the north and of the Branisko Series to the south (Birkenmajer, 1953, 1957a, Birkenmajer-Znosko, 1955).

Notwithstanding the many features common with the other Klippen Series, the individuality of the Niedzica Series is quite clear. As to the

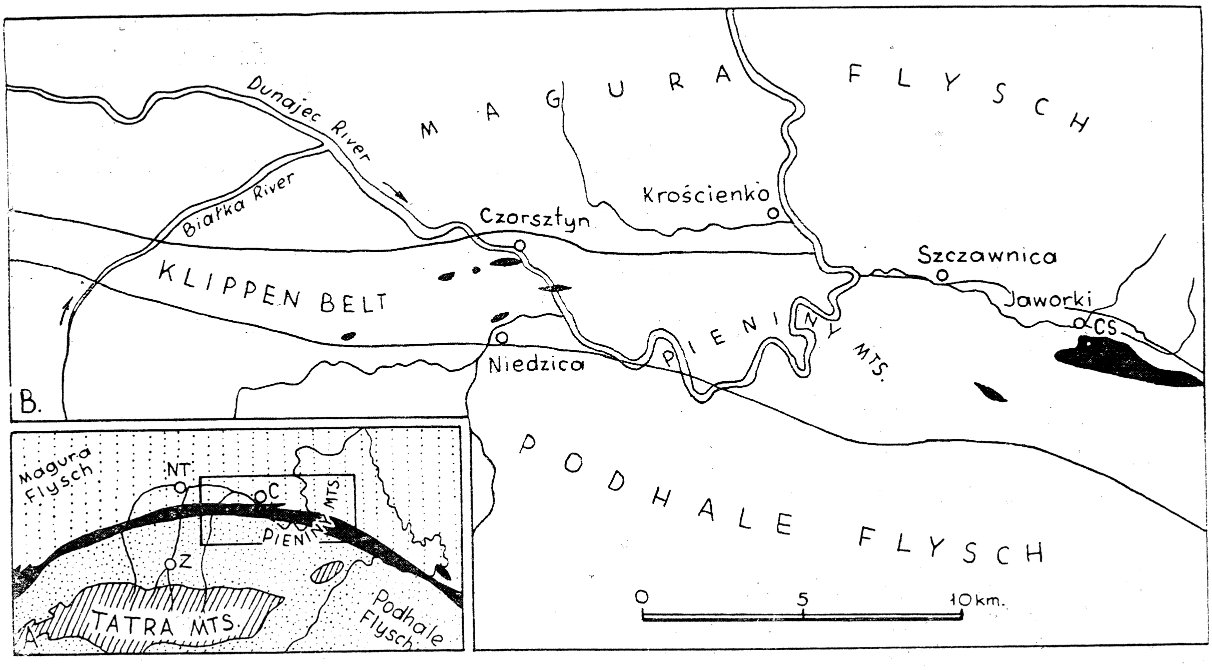

Fig. 1. A. The position of the Pieniny Klippen Belt in the Carpathians. A rectangle marks the region indicated in Fig. 1 B; C — Czorsztyn, NT — Nowy Targ, Z — Zakopane

B. Outcrops of the Niedzica Series in the Klippen Belt of Poland (after Birkenmajer, 1959 a, simplified). The klippes of the Niedzica Series in black. CS — Czajakowa Skała not individual features, from the Aalenian to the Callovian the Niedzica Series has more in common with the Czorsztyn Series than with the Branisko Series, and from the Callovian upwards the relation is reversed.

In the Subhercynian movements the Niedzica Series has been torn up and dragged as blocks and lenses below the Branisko Nappe northwards over the Czorsztyn Series, then autochthonous (Birkenmajer, 1958a). Subsequent tectonic movements deformed the Niedzica Series still more. The very great tectonic deformation makes difficult the investigations of the stratigraphy of the Niedzica Series.

The Niedzica Series in the Polish part of Spisz and near Szczawnica occurs now as small klippes separated by rocks belonging to other series. East of Szczawnica, in the environs of Jaworki and Biała Woda, however, the klippes of the Niedzica Series are greater (Birkenmajer, 1959a) (Fig. 1), and outcrops are better. It is in this region that the exotic fragments have been found.

GEOLOGICAL POSITION OF THE EXOTIC FRAGMENTS

Localization of the Exotic Fragments

Czajakowa Skała is a klippe situated on the right side of the gorge Homole near Jaworki east of Szczawnica. It has been described for the first time by V. Uhlig (1890, Fig. 31, 33), who considered it to be formed by the Subpieniny (Czorsztyn) Series rocks. The same view was held by L. Horwitz and F. Rabowski (1929), though on a profile included in their paper (op. cit., Fig. 7) radiolarites were marked. K. Birkenmajer (1953) considers Czajakowa Skała [1] to be formed by the Niedzica Series rocks. This view is adopted in the present paper. A detailed description of the stratigraphical sequence in the Czajakowa Skała is given by Birkenmajer (1958a, Excursion No 20); see Fig. 2.

In the SE. part of the klippe Czajakowa Skała there is a nearly vertical dip-slope about 15 metres high, formed by the Lower Nodular Limestone. This limestone can be subdivided into:

c. dark red nodular limestone	1.2 m. thick
b. dark red thin bedded haematite marl	0.5 m. thick
a. dark red nodular limestone	6.0 m. thick
total thickness	7.7 m.

The exotic fragments occur in the lower part (a), c. 1.3 m. from the sedimentary contact of the Lower Nodular Limestone with the Red Crinoidal Limestone, and c. 7 m. above the scree at the foot of the dip-slope. Their occurrence is limited to an elliptical surface c. 2 square metres, parallel to the stratification. The longer axis of the surface when turned to a horizontal position runs NW-SE. There are 32 exotic fragments. They are scattered in a haphazard way with the exception of

[1] Described (op. cit.) under the name „Upper Homola Gorge".

a not too distinct increase of concentration of greater fragments towards SE. (fig. 3A.). Some fragments must have lain on the bottom on their flat sides; the smaller ones presumably indicate the position of the bottom

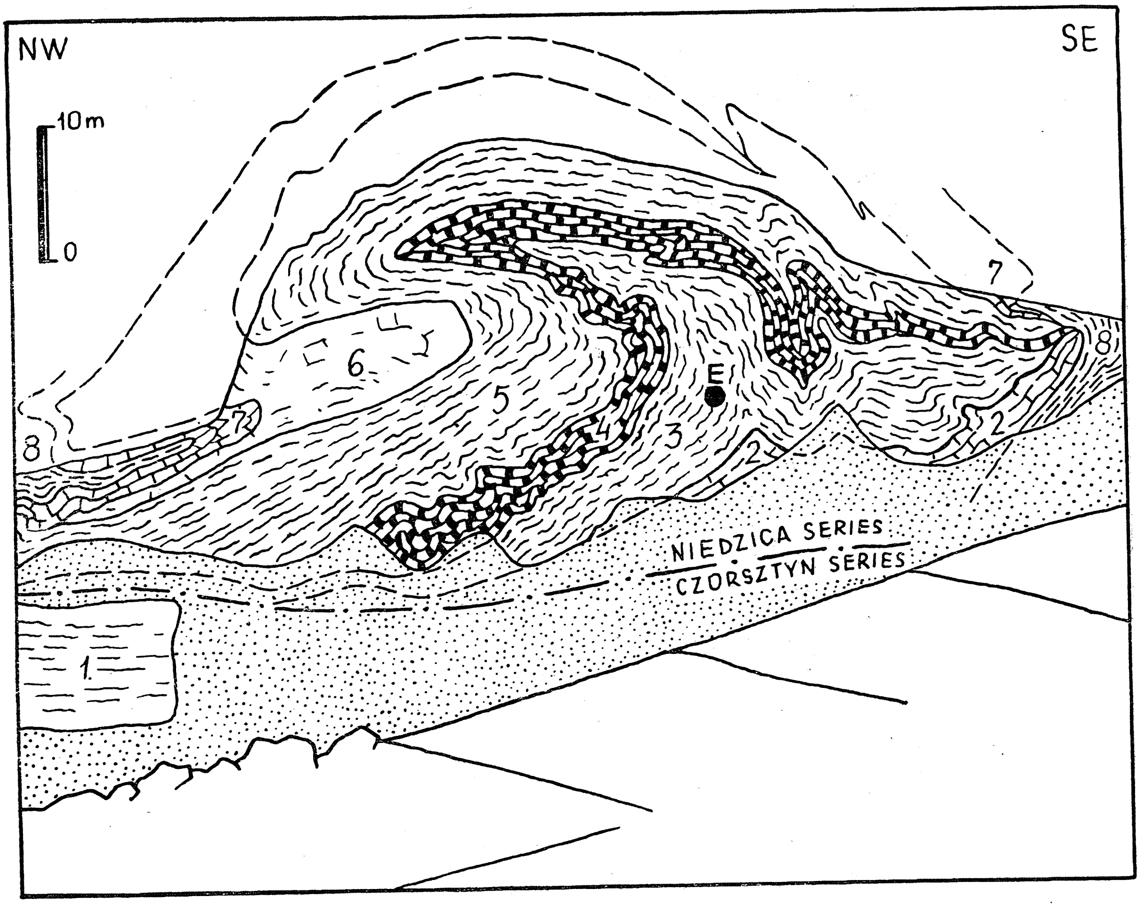

Fig. 2. Profile of Czajakowa Skała near Jaworki (after Birkenmajer, 1958a, fig. 116, modified). The Czorsztyn Series: 1. Nodular Limestone (Callovian to Kimeridgian). The Niedzica Series: 2. Red Crinoidal Limestone (Bajocian), 3. Lower Nodular Limestone (Bathonian-Callovian), — the position of exotic fragments is marked by a thick dot indicated by the letter E, 4. Lower Red Radiolarites, Green Radiolarites, Upper Red Radiolarites (Oxfordian), 5. Upper Nodular Limestone (Kimeridgian), 6. Calpionella Limestone (Tithonian), 7. Pseudocherty Limestone (Valanginian-Hauterivian), 8. Beds with globigerinids and radiolarians (Barremian--Albian). Scree marked with dots

on which they have been deposited, while the greater ones have sunk a little in the sediment. Other fragments are enclosed in the sediment obliquely or perpendicularly to the stratification (Fig. 3B).

The enclosing nodular limestone consists of distinct limestone nodules separated by a marly substance. Some nodules are deformed internal moulds of shells of ammonites and nautiloids up to a few score centimetres in diameter. The nodular limestone is strongly coalesced with the exotic fragments. The nodules immediately above (in the stratigraphic sense) the greater exotic fragments are somewhat flatter than the usual nodules. Nodules below the greater exotic fragments have been completely destroyed by erosion. It seems that the fragments did not form the nuclei of the nodules, nor did the marly substance tend to accumulate on their surfaces. Their relation to the particular nodules seems quite haphazard.

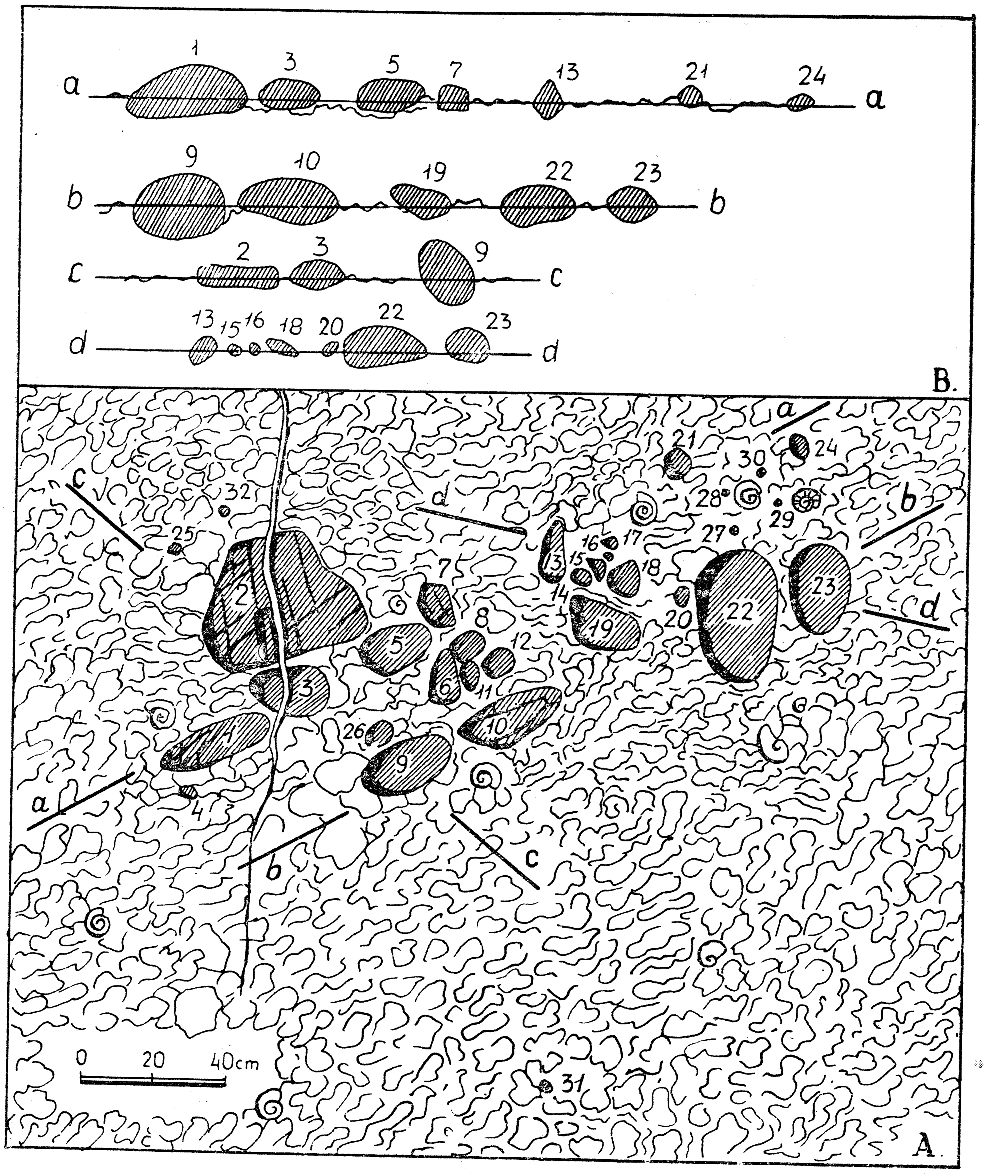

Fig. 3. A. Position of the exotic fragments in the Lower Nodular Limestone on bottom of the layer
B. *a-a*, *b-b*, *c-c*, *d-d* — transversal sections of the layer with the exotic fragments (cf. Fig. 3A)

The small amount of sinking into the bottom seems to indicate that the sediment has not been very soft when they fell down. It seems, therefore, that the nodules were already formed, and the sediment partly diagenezed, when the exotic fragments fell down.

In some of the exotic fragments jointing is visible. It does not pass into the enclosing rock. Some joint cracks are filled with calcite, others are empty. These phenomena could result owing to difference in competence of the exotic fragments and of the enclosing rock.

Petrographic Character and Shape Analysis of the Exotic Fragments

The Table given below (Table 1) contains the complete list of exotic fragments in question. Particular fragments are designated by the same numbers as in Figure 3A. The petrographic character of igneous and metamorphic rocks has been determined by T. Wieser. Diametres a, b, c, are at right angles, but do not always cross one another.

It has been assumed that all the exotic fragments are of an approximately ellipsoidal shape. The approximate weight has been obtained by multiplying the volume of a fragment obtained on the above assumption by 2.7 (mean specific weight of Sial after Umbgrove, 1947).

Zingg's (1935) diagram has been used (Fig. 4) to compare the relations $\frac{c}{b}$ and $\frac{b}{a}$ of the particular fragments. As the quantity of the exotic fragments was small, we did not take into account the size and the petrographic character.

The relation $\frac{a+b}{2c}$, which according to A. Cailleux (1945) clearly depends on the rounding agent, was determined for the particular fragments (cf. Table 1).

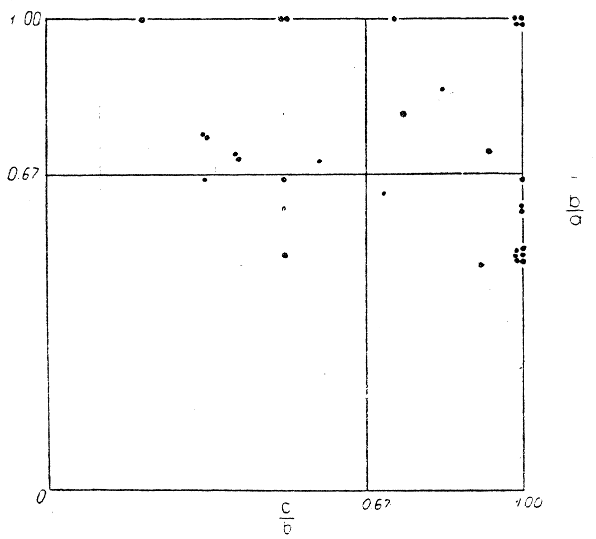

Fig. 4. Relations $\frac{b}{a}$ and $\frac{c}{b}$ in Zingg's diagram

Sphericity has been determined according to Wadell's „practical formula" $\psi = \frac{d_n}{D_s}$, where ψ is sphericity, d_n — the diameter of a sphere of the same volume as the fragment, D_s — the longest diameter of the fragment (cf. Krumbein, 1938, pp. 292—294). The results are presented in Table 1.

Table 1

Petrographic and sedimentological character of the exotic fragments

Number	Petrographic character	Colour	Roundness	Dimensions in cms			Volume in cubic cms.	Weight in grams	Relations of axes			Sphericity ψ
				a	b	c			$\frac{c}{b}$	$\frac{b}{a}$	$\frac{a+b}{2c}$	
1	microgranitic quartz porphyry	violet	subrounded	30	20	10	3135	8 464	0,50	0,66	2,5	0,60
2	felsophyric quartz porphyry	red	subrounded	45	30	10	7054	19 046	0,33	0,66	3,7	0,44
3	microgranitic quartz porphyry	violet	rounded	20	10	10	1045	2 821	1,00	0,50	1,5	0,63
4	felsophyric quartz porphyry	red	subangular	2	2	1	2	5	0,50	1,00	2,0	0,78
5	granophyric quartz porphyry	light violet	rounded	15	10	10	784	2 117	1,00	0,66	1,2	0,77
6	felsophyric quartz porphyry	light violet	subrounded	10	6	3	94	254	0,50	0,60	2,7	0,56
7	cinereous tuff	dark red	subangular	10	7	4	146	394	0,57	0,70	2,1	0,66
8	bi-mica gneissoid granite	pink	subangular	5	4	3	31	84	0,75	0,80	1,5	0,78
9	granophyric quartz porphyry	light violet	rounded	22	14	10	1609	4 344	0,71	0,63	1,8	0,66
10	granophyric quartz porphyry	light violet	subrounded	25	12	11	1724	4 655	0,91	0,48	1,7	0,60
11	granophyric quartz porphyry	light violet	rounded	5	3	3	23	62	1,00	0,60	1,3	0,70
12	felsophyric quartz porphyry	light violet	subrounded	10	10	2	104	281	1,00	0,60	5,0	0,58
13	biotite augen-gniess	pink and black	subrounded	10	5	5	131	354	0,20	1,00	1,5	0,64
14	felsophyric quartz porphyry	red	rounded	3	2	2	6	16	1,00	0,66	1,2	0,78

15	biotite gneissoid granite	greenish-black	subangular	7	5	2	37	100	0,40	0,71	3,0	0,59
16	cinerous tuff	dark red	subangular	2	1	1	1	3	1,00	0,50	1,5	0,63
17	microgranitic quartz porphyry	violet	subangular	2	2	1	2	5	0,50	1,00	2,0	0,78
18	granophyric quartz porphyry	violet	rounded	7	5	2	37	100	0,40	0,71	3,0	0,59
19	microgranitic quartz porphyry	violet	rounded	15	15	11	1291	3 487	0,73	1,00	1,4	0,90
20	felsophyric quartz porphyry	light violet	subangular	4	2	2	8	22	1,00	0,50	1,5	0,63
21	granophyric quartz porphyry	violet	rounded	7	6	5	110	297	0,83	0,85	1,3	0,74
22	felsophyric quartz porphyry	light violet	rounded	40	20	10	4180	11 286	0,50	0,50	3,0	0,50
23	limestone with algues	grey	rounded	22	16	15	2759	7 449	0,93	0,72	1,2	0,79
24	granophyric quartz porphyry	violet	rounded	4	3	1	6	16	0,33	0,75	3,5	0,56
25	felsophyric quartz porphyry	red	subangular	2	1	1	1	3	1,00	0,50	1,5	0,63
26	muscovite gneiss	grey	subangular	5	4	2	21	57	0,50	0,80	2,2	0,68
27	aplite	red	subangular	4	3	1	6	16	0,33	0,75	3,5	0,56
28	granophyric quartz porphyry	violet	subangular	0,5	0,5	0,5	0,06	0,16	1,00	1,00	1,0	1,00
29	granophyric quartz porphyry	violet	subangular	0,5	0,5	0,5	0,06	0,16	1,00	1,00	1,0	1,00
30	granophyric quartz porphyry	violet	subangular	0,5	0,5	0,5	0,06	0,16	1,00	1,00	1,0	1,00
31	microgranitic and micropegmatitic quartz porphyry (contact)	pink	subangular	0,5	0,5	0,5	0,06	0,16	1,00	1,00	1,0	1,00
32	granophyric quartz porphyry	light violet	subangular	1	0,5	0,5	0,13	0,35	1,00	0,50	1,5	0,66

Roundness has been determined according to Pettijohn's (1949, pp. 51—53) scale (Table 1 and 2).

Table 2

Roundness of the exotic fragments

Roundness	Frequency	Percentage
Angular	—	—
Subangular	15	46,9
Subrounded	6	18,7
Rounded	11	34,3
Well rounded	—	—
	32	99,9

The results of the shape analysis of our exotic fragments do not allow more than tentative conclusions. The quantity of our fragments is smaller than that generally used in sedimentological study, and the size and the petrographic character could not be taken into account to such an extent as they generally are. This somewhat invalidates comparisons. Besides, the quantity of our fragments is very small. In the last place, it must be assumed that all our fragments derived from the same environment. Nevertheless, the results of the shape analysis permit us to advance certain suggestions as to the sediments our fragments derived from.

The relations $\frac{c}{b}$ and $\frac{b}{a}$ of our fragments which are mostly (74.9 per cent of quantity — cf. Table 3) porphyry do not differ much from the same relations obtained for the granite pebbles 64—128 mm. long in the upper course of the river Dunajec (after 59 km. of transport — cf. Unrug, 1957, Fig. 12A). According to A. Cailleux (1945, p. 394) the relation $\frac{a+b}{2c}$ for the porphyry river fragments oscillates with great variations about 1.8, and for the porphyry beach fragments about 2.4. For our porphyry fragments, the mean arithmetic relation $\frac{a+b}{2c}$ is 2.0 (Table 3). The degree of roundness of our fragments, which is not high, is another difference from the beach fragments, which are usually very well rounded.

It seems, therefore, that the shape of our fragments resembles rather the shape of the alluvial fragments than that of the beach fragments. This means that our fragments derived rather from alluvial deposits than from beach deposits, as, according to Cailleux (op. cit., p. 400): „Ainsi se trouve écartée une importante cause d'erreur dans l'étude des formations anciennes: au voisinage d'une embouchure, le matériel fluviatile, repris par la mer, perd très vite son caractère fluviatile".

Sedimentary Conditions of the Lower Nodular Limestone

The terrigenic admixture in the Lower Nodular Limestone consists almost exclusively of clay (sensu Pettijohn, op. cit., pp. 12—13). The only fragments greater than clay hitherto found are the above described exotic fragments.

The continuous and very slow sedimentation, the apparent uniformity in the horizontal sense, the sedimentary contact with the radiolarites, and the lack of terrigenic material greater than clay, taken together, imply a sedimentation in pelagic and bathyal, if not abyssal, conditions.

This conclusion seems valid also for other nodular limestones in the Pieniny Klippen-Belt [1].

Age of the Lower Nodular Limestone

As to the age of the Lower Nodular Limestone, the following data are available.

In the lower part of the Lower Nodular Limestone in a klippe near the village Niedzica have been found (Birkenmajer and Znosko, 1955): *Coenoceras calloviensis* (Opp.), *Parkinsonia* sp., pro parte ex gr. *parkinsoni* (Sow.), pro parte cf. *calloviensis* (Loczy), *Cadomites* sp. pro parte cf. *C. rectelobatum* (Hau.), *Phylloceras* cf. *viator* (D'Orb.), *Ph. kudernatschi* (Hau.), *Calliphylloceras disputabile* (Zitt.), *C.* cf. *disputabile* (Zitt.), *Nannolytoceras tripartitum* (Rasp.), etc. This fauna indicates the highest Bajocian? — Bathonian — Callovian age. In the same klippe Laevaptychi occur exclusively in the upper part of the Lower Nodular Limestone. Laevaptychi appear somewhere between the *macrocephalus* and *lamberti* zones.

In the Lower Nodular Limestone in a klippe of the Pruské Series (equivalent to the Niedzica Series) in the valley Podhradska in Western Slovakia, have been found (Andrusov, 1953, p. 38 (350)): *Phylloceras kudernatschi* (Hau.), *Nannolytoceras tripartitum* (Rasp.), *Cadomites rectelobatum* (Hau.). This fauna indicates a Bathonian-Callovian age.

In the Czajakowa Skała in the lower part of the Lower Nodular Limestone (a) have been found some Phylloceratids, Lytoceratids, Perisphinctids and Cadomites. They have not been more exactly determined, but they seem identical with the ammonites from the klippe near Niedzica listed above. The lower limit of the Laevaptychi is simultaneous with the contact of the middle (b) and the upper (c) parts of the Lower Nodular Limestone. It seems therefore that this part of the Nodular Lower Limestone in Czajakowa Skała which contains the exotic fragments is of a Bathonian age.

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[1] Andrusov, 1953, p. 22 (334) and p. 44 (356) considers all the nodular limestones in the Pieniny Klippen-Belt as bathyal sediments.

MODE OF TRANSPORTATION OF THE EXOTIC FRAGMENTS

We shall assume that all the above described exotic fragments have been transported into the Lower Nodular Limestone sedimentary region simultaneously and in the same way. In view of what was said above, this assumption seemed quite justified.

Volcanic eruption is a possible transporting agent. Nevertheless it must be excluded as no traces of volcanic activity have been found in the Dogger of the Pieniny Klippen-Belt.

Turbidity currents and submarine slumps can transport great rock fragments from the littoral to the bathyal or abyssal zones. However, the extreme scarcity of coarse clastic material and the lack of graded bedding and other significant features (cf. Kuenen, 1953, Książkiewicz, 1954) in the Lower Nodular Limestone lead us to the exclusion of a turbidity current or of a submarine slump as the transporting agent of our fragments.

Drifting ice can easily transport rock fragments over great distances. Lack of striae on our fragments does not exclude their glacial origin, as the percentage of striated fragments in glacial sediments is sometimes very small (cf. Wentworth fide Pettijohn, 1949, p. 57). It seems, however, that the climatic conditions of the time would not have allowed the formation of glaciers. No evidence of glaciation has been found in the whole Jurassic of the Tethys region (Arkell, 1956). On the other hand, there is evidence of a rather warm climate. It is only in California that Jurassic tillites have been found (fide Umbgrove, 1947, p. 261, Fig. 161). Arkell, however, does not mention them in his monograph of the Jurassic (op. cit.).

That our fragments are not gastrolithes appears from the lack of glaziness (cf. Abel, 1935, pp. 310—317). That they have been inadvertently swallowed seems improbable in view of their size (65.7 kgs.) [1].

Rafting of rocks by algae is another possible transportation agent. It seems, however, that our fragments weigh too much for such a mode of transport (for bibliography vide Emery, 1955; Shumway, 1956).

Drifting wood or „floating islands" of tangled growth can travel over great distances. They may carry in their roots fragments of rocks. The subject has been recently treated by Emery (op. cit.). The most impressive of the many instances mentioned by this author are the following„...a kauri tree afloat in the Gulf of Papua. This tree was three metres in diameter... Held by its roots was a boulder three or four metres in diameter... The sighting was about 150 miles off the Fly River, which was probably the source... The tree had been in the sea long enough, however, for boring organisms and barnacles to become established", and „...pines a meter in diameter cast ashore on Nonouti Island that carried by their roots stones of fine-grained basalt of all sizes; he (Hartzer) believed that the trees came from New Zealand 1200 miles away" (op. cit., pp. 52—53).

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[1] For bibliography on transportation of rock fragments by animals vide Emery (1955), and Fleming (1951).

The Middle Jurassic Coniferous trees seem to have been quite able to hold by their roots rock fragments of such a size as ours (65.7 kgs.) and to drift despite this encumbrance for a long time.

It seems therefore that the following mode of origin of our fragments is the most probable. A tree, or a mass of smaller plants, growing upon an alluvial deposit, containing entangled in its roots our rock fragments, has been torn off by a flood. Subsequently it has been carried to the sea, where it drifted for some time. When putrefaction advanced sufficiently it sunk and our fragments have been deposited on a small area of the bottom in the Lower Nodular Limestone sedimentary region.

MACROCLASTIC EXOTIC FRAGMENTS IN THE RADIOLARITES AND IN THE BIANCONE IN THE PIENINY KLIPPEN BELT

As in the Lower Nodular Limestone, so in the other nodular limestones, in the radiolarites and in the biancone in the Pieniny Klippen Belt macroclastic exotic fragments are extremely rare. It is impossible to determine their density per square kilometer of the bottom, but some idea of their scarcity may be obtained if one considers that the first author has inspected many thin plates and mapped the Pieniny Klippen Belt for eight years, and the second author has collected fossils from the rocks in question for three years, and the only macroclastic fragments found — besides the fragments from Czajakowa Skała — are the following:

1. Quartz, pale blue, opaque, well rounded, 1.2 × 1.0 × 0.9 cms., enclosed in the marl between the nodules, passage beds between the Pseudo-Nodular Limestone (Kimeridgian) and the Biancone (Tithonian-Barremian), Branisko Series, klippe Stronia in the Pieniny Mts.

2. Quartz, colourless, transparent, subangular, 0.4 × 0.3 × 0.2 cm., on the surface of a layer [1], Green Radiolarites (Upper Oxfordian) [2], Niedzica Series, Buwałd klippe in the valley Kosarzyska near Falsztyn in Spisz.

3. Quartz, white, opaque, well rounded, 0.13 × 0.13 × 0.07 cm., on the surface of a layer, Upper Red Radiolarites (Upper Oxfordian) [2], Niedzica Series, klippe Pod Czerwoną, valle of the Skalski stream near Jaworki.

4. Quartz, green, transparent, subrounded, 0.5 × 0.4 × 0.4 cm., on the surface of a layer, Green Radiolarites (Upper Oxfordian), [2] Branisko Series, klippe on the SW. slope of the mountain Flaki, Pieniny Mts.

5. Cristalline schist, fine grained, dark rose, angular, 0.8×0.6×0.6 cm., on the surface of a layer, Biancone (Valanginian-Barremian), Branisko Series, quarry near the road from the bridge on the Poprad to Ujak (Czechoslovakia).

Both radiolarites and biancone are, in the Pieniny Klippen Belt, pelagic and deep sea sediments (cf. Sujkowski, 1932, Andrusov, 1953). Macroclastic exotic fragments listed above must have derived

[1] It has not been possible to distinguish between the lower and the upper surfaces, as all the exotics listed here have been found enclosed in loose fragments of rocks.

[2] Upper Oxfordian in Arkell's (1956) sense.

either from land or from the littoral zone. The mode of their transportation could have been the same as that suggested by us for the exotic fragments in the Lower Nodular Limestone of Czajakowa Skała (vide supra), or they could have been rafted by algae torn off by wave action. Obviously eolic transport must be excluded.

It can be suggested here, that, in view of what has been said above about the macroclastic exotic fragments in the pelagic and deep water sediments in the Pieniny Klippen Belt, the fragments of silicified wood found in the radiolarites in the Schistes Lustrés zone of the Alps and in the Dinantian radiolarites in Southern France (fide Gignoux, 1950, p. 401, n. 3) should not be accepted as evidence of a near shore and shallow water origin of their respective enclosing rocks.

It could be also suggested that the exotic fragments contained in the Bathonian limestones of the High Tatra Series between Wielka Świstówka and Mała Świstówka in the Tatra Mts. (Passendorfer, 1951, p. 51) and in the Albian glauconite limestones of the High Tatra Series in the Tatra Mts. (Passendorfer, 1930, pp. 369—370, 533—535; 1951, p. 75), have been transported into their enclosing sediments in a similar way as the exotic fragments from Czajakowa Skała.

PROVENANCE OF EXOTIC FRAGMENTS FOUND IN CZAJAKOWA SKAŁA

The presence of certain rock types among our fragments, and the relation between the number of fragments of certain rock type and their volume (Table 3), must have been controlled by the abrasion agent [1]. This must be taken into account when using our fragments in palaeogeographic considerations.

The petrographic character of our fragments implies that the simplest possible structure of the land they derived from must have been the following. There was a cristalline massif containing muscovite, biotite, and muscovite-biotite gneisses and gneissoid granites. It was intruded with aplites in its lower part, and with various subvolcanic porphyries: microgranitic and micropegmatitic quartz porphyries and with granophyres in its upper part. With these intrusions were connected the extrusions of felsophyres and of porphyric tuffs. As all these magmatic rocks are comagmatic, they have probably been formed in the same cycle of magmatic activity. Both the cristalline schist massif and the magmatic rocks have been covered by sedimentary rocks represented among our fragments by a piece of limestone.

If we assume that our fragments derived from within the central or

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[1] If we are right in suggesting that our fragments derived from river deposits, comparisons with the selective abrasion of present rivers could give some idea of the lenght of transport. For example, in the upper course of the river Dunajec, fragments of mica-schists persist over the distance of 3 km., of amphibolites — 35 km., of limestones — 50 km., of gneisses — 90 km.; after 90 km. remain only well rounded fragments of quartzites and of granites. Generally speaking, all rocks of small resistance are practically eliminated over the distance of 35 km. (Unrug, 1957). It seems that our fragments have not been transported by a river over a long distance.

Table 3

Sedimentological character of petrographic groups of the exotic fragments

	Petrographic group	Numbers of exotics	Frequency	Percentage of quantity	Volume in cubic cms.	Percentage of volume	Weight in grams	Mean arithmetic sphericity ψ	Mean arithmetic $\frac{a+b}{2c}$
A.	limestone	23	1	3,1	2 759	11,3	7 449	0,79	1,2
B.	cinereous tuff	7 ; 16	2	6,2	147	0,6	397	0,64	1,8
C.	felsophyric quartz porphyry	2 ; 4 ; 6 ; 12 ; 14 ; 20 ; 22 ; 25	8	25,0	11 449	47,9	30 912	0,60	2,0
D.	granophyric quartz porphyry	5 ; 9 ; 10 ; 11 ; 18 ; 21 ; 24 ; 28 ; 29 ; 30 ; 32	11	34,3	4 293	17,6	11 591	0,75	
E.	microgranitic quartz porphyry	1 ; 3 ; 17 ; 19	4	12,5	5 473	22,4	14 777	0,72	
F.	microgranitic and micropegmatitic quartz porphyry (contact)	31	1	3,1	0,06	0,0002	0,16	1,00	
G.	aplite	27	1	3,1	6	0,02	16	0,56	—
H.	gneissoid granite, muscovite-gneiss, augen-gneiss etc.	8 ; 13 ; 15 ; 26	4	12,5	22	0,9	594	0,67	2,1
		total value	32	99,8	24 347	100,7	65 736	—	—

the western parts of the Carpathian geosyncline or from its environs, certain suggestions can be made as to their age.

As all the cristalline schists now exposed in these areas are considered with good reason to be pre-Uper Carboniferous, it can be suggested that our gneisses are of the same age. In the cristalline massifs in the Inner Carpathians [1] and in the Sudeten Mts. [2] there are Upper Carboniferous Suplutonic intrusions. Our aplites could be of the same age. In the Sudeten Mts., in the Cracow area and in the Verrucano formation in the river Hron region in the Inner Carpathians [3] there are Lower Permian subvolcanic and extrusive porphyries. Our porphyries could be of the same age. Our limestone with calcareous algae is rather Triassic than Liassic, as it seems that in the Carpathian geosyncline there were areas transgressed by the Triassic sea emerged for some time during the late Triassic and Lower Jurassic, but no areas are known which were under sea in the Liassic and emerged in the Dogger (cf. Andrusov 1938 b; Książkiewicz, 1954 b, 1956).

The above considerations are resumed in the following Table 4:

Table 4

Probable age of exotic fragments from Czajakowa Skała

Middle Triassic	limestone with calcareous algues
Werfenian	?
Upper Permian	?
Lower Permian	extrusions of felsophyres and porphyric tuffs; intrusions of microgranitic and micropegmatitic quartz porphyries and of granophyres
Upper Carboniferous	aplites — apophyses of intrusions of granites (?)
Pre-Upper Carboniferous	muscovite gneisses, biotite augen-gneisses, biotite gneissoid granites, biotite-muscovite gneissoid granites and hornfelsed (pelite) gneiss (?)

It is of course more probable that our fragments derived from a land near the Pieniny Klippen Belt geosyncline than that they derived from a remote land. We shall, therefore, try to fit our fragments above all into the areas nearest the Pieniny Klippen Belt geosyncline. These are:

a. The geanticlinal area inside the Pieniny Klippen Belt sedimentary basin,

b. The geanticlinal area south of the Pieniny Klippen Belt sedimentary basin,

c. The geanticlinal area north of the Pieniny Klippen Belt sedimentary basin.

The geanticlinal area inside the Pieniny Klippen Belt basin was situated between the Niedzica Series basin and the Branisko Series basin (Birkenmajer, 1957 b). It appeared for the first time in the Lower Aalenian, when it was emerged and furnished clastics to the flysch deposits of the Branisko Series and of the Niedzica Series. These deposits contain

[1] cf. Michalik (1951).

[2] cf. Teisseyre and others (1957).

[3] A summary on the geology of the Inner Carpathians is given by Andrusov (1938 b).

few fragments of exotic Middle Triassic limestones and dolomites. This cordillera has been partly submerged in the Middle Aalenian. From the Bajocian till the Barremian this geanticlinal area has been completely submerged. It emerged for the second time in the Aptian and in the Albian, when it furnished clastics for the siltstones in the upper part of „the beds with globigerinids and radiolarians" in the Niedzica and in the Branisko Series. These siltstones contain no macroclastics (B i r k e n m a j e r, 1957 b, c, 1958 a, 1959 a; B i r k e n m a j e r and N a r ę b s k i, 1958).It appears from this resumé of the history of the geanticlinal area inside the Pieniny Klippen Belt basin that our fragments could not have derived from it.

The geanticlinal area south of the Pieniny Klippen Belt basin was situated between the Pieniny Klippen Belt basin and the High Tatra Series (sensu lato) basin. It furnished clastics to the Cenomanian Orlové Sandstones of the Manín Series in the valley of the Váh river. These sandstones contain exotic fragments of Jurassic and Cretaceous rocks, of quartzites of the Werfenian age and of quartz porphyries which have not been more exactly determined but according to D. A n d r u s o v (1945, 1953) are similar to those contained in the Upper Cretaceous sedimentary mantle of the Klippen Series. The supply of the clastics, as indicated by flute and drag casts, was from the NE or ENE, and with a great probability the source area was situated along the northern border of the Manín Series basin (B i r k e n m a j e r, 1958 b). The Manín Series basin was situated immediately south of the geanticlinal area south of the Pieniny Klippen Belt Basin (B i r k e n m a j e r, 1958 c). As in the Cenomanian and in the Lower Turonian pelagic Globotruncana Marls have been deposited in the Klippen Series Basin (B i r k e n m a j e r, 1957 a), the clastics in the Orlové Sandstones could not have derived from an area north of the Pieniny Klippen Belt basin.

Also from the south must have derived the exotic fragments contained in the Upper Turonian Flysch of the Klippen Series in Poland (B i r k e n m a j e r 1958 a, Birkenmajer and K o k o s z y ń s k a, 1958), in the pre-Laramide sedimentary mantle of the Klippen Belt: the Úpohlav Beds in Western Slovakia (A n d r u s o v, 1938 a, 1945, 1953) and in the adjacent part of the Klippen Belt in Poland (Birkenmajer, 1958 a), and the Jarmuta Beds in Poland (B i r k e n m a j e r, 1956, 1957 c, 1958 a), and in the post-Laramide sedimentary mantle of the Klippen Belt: in the Złatne Beds (Lower Eocene) in Poland (B i r k e n m a j e r, 1958 a).

V. Z o u b e k (1931) and D. A n d r u s o v (1938 a, 1945, 1953) described the exotic fragments from the Úpohlav Beds. A n d r u s o v attempted besides to reconstruct the stratigraphic sequence in the land of their provenance. According to this author, pre-Carboniferous is represented by orthogneisses, augen-gneisses and phyllites, pre-Middle Carboniferous — by green granites and by granites similar to the granites in the Tatra Mts., the younger Palaeozoic — by arkose sandstones, coarse grained sandstones and black shales (Carboniferous?), and green, yellow and red, extrusive and also, according to Zoubek (1931), intrusive, porphyries, the Triassic — by red quartzites (Werfenian), melaphyric porphyries (not determined more exactly), red and green shales (Werfenian), limestones and dolomites (Middle Triassic), red shales (Keuper). Besides, there occur fragments of Jurassic and Cretaceous rocks. This series Andrusov considered to have constituted the older part of the Pieniny Series sequence. Birkenmajer (1958 a), however, considers the series reconstructed by Andrusov to be connected not with the Pieniny Series sensu lato, but with an „exotic" Mesozoic series, situated between the sedimentary basin of the Klippen Series and of the High Tatra Series sensu lato.

The exotic fragments in the Turonian flysch of the Klippen Series and in the Upper Cretaceous and Lower Eocene Klippen Mantle in Poland have been described by T. Wieser (1958) and K. Birkenmajer (1958 a). Have been determined: spilites (= melaphyric porphyries of Zoubek and Andrusov), propylites, felsites, quartz albitophyres (= porphyries in Zoubek and Andrusov op. cit.), albitophyres without quartz, tuffoids, albitized sandstones, adinoles, albite granites, protogines (alaskites), albite granodiorites, etc. It appears that they are very similar to the exotic fragments from the Úpohlav Beds listed above.

It seems therefore that in the geanticlinal area between the Pieniny Klippen Belt basin and the High Tatra Series basin all the magmatic rocks have been connected with a distinctly alcaline province. As our exotic fragments are calcareo-alcaline, they rather should not have derived from this area.

A few words should be said about the area situated southward of the above described area, i.e. the area occupied by the High Tatra Series. The substratum of the High Tatra Series is formed by a massif consisting of granite and oi crystalline schists. The High Tatra Series area has been partly emerged in the Liassic and in the Dogger (Passendorfer, 1951), and so it could have been the land of provenance of our exotic fragments. On the other hand, the petrographic character of the substratum of the High Tatra Series is quite different from that of our fragments [1].

The geanticlinal area north of the Pieniny Klippen Belt basin was situated north of the Czorsztyn Series sedimentary region and south of the Četechovice trough and its probable eastward extension. In other words, it was situated on the border of the sedimentary regions of the Inner and Outer Carpathians.

From this area derived the fragments of quartz (probably from feebly diagenezed Werfenian sandstones), of Middle Triassic limestones and dolomites, and of red shales (Keuper?) contained in the Bajocian and Bathonian crinoidal limestones of the Czorsztyn Series and in the Bajocian crinoidal limestones of the Niedzica Series in Poland and in Western Slovakia described by Andrusov (1953, p. 326—327) and K. Birkenmajer 1958 a, K. Birkenmajer and W. Narębski, 1958). The size and frequency of these fragments diminishes southward, and therefore they must have derived from the north (Birkenmajer op. cit.).

From the lack of fragments of plutonic and metamorphic rocks it appears that erosion did not reach there the cristalline substratum. This, however, does not exclude that our fragments derived from the

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[1] For bibliography on the cristalline substratum of the High Tatra Series vide Michalik (1951).

geanticlinal area north of the Pieniny Klippen Belt basin as in other places erosion could have reached the cristalline substratum.

The cristalline substratum of the Outer Carpathians has been reconstructed from the exotic fragments contained in the Lower Cretaceous rocks of the Subsilesian Nappe, in the Upper Cretaceous rocks of the Silesian Nappe, and in the Krosno Beds (Oligocene) (G a w e ł, 1932; W i e s e r, 1950, 1954; K s i ą ż k i e w i c z, 1953, 1954, 1956; K s i ą ż k i e w i c z and W i e s e r, 1954). It appears that petrographic character of the crystalline substratum of the Outer Carpathians is quite different from that of the geanticlinal area south of the Pieniny Klippen Belt.

Certain rocks represented among the exotic fragments derived from the substratum of the Outer Carpathians are somewhat similar to the rocks represented among our fragments, e.g. biotite-muscovite gneisses and quartz porphyries. A most striking resemblance exists between the petrographic character of our fragments and that of the exotic fragments from the Magura Sandstone (Eocene-Oligocene?) in the mountain Dzwonkówka near Krościenko, i.e. very near the northern contact of the Pieniny Klippen Belt. The latter fragments have been determined by J a x a - B y k o w s k i (1925) as: quartz porphyries, orthophyries and porphyritic rocks (all extrusive), biotite gneissoid granites, muscovite-oligoclase gneisses, andesine gneisses, muscovite-oligoclase-garnet gneisses. These fragments must have derived from the north [1].

It seems, therefore, that our fragments could have derived from the cristalline substratum of the Outer Carpathians. The southernmost part of this substratum, i.e. the geanticlinal area immediately north of the Pieniny Klippen Belt basin, could have originated our fragments most

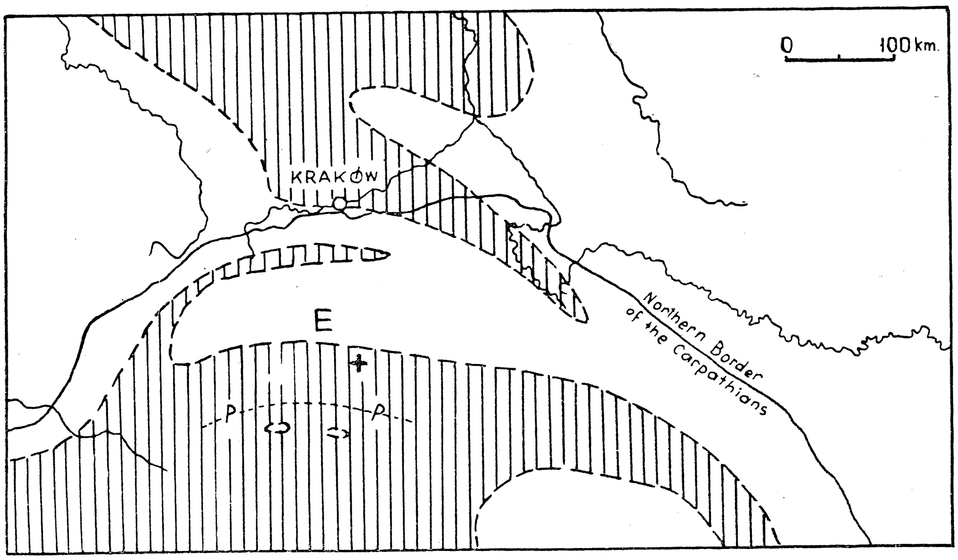

Fig. 5. Position of the exotics from Czajakowa Skała (+) within the Bathonian in the Carpathians. P-P — probable limit of the Pieniny Klippen Belt sedimentary region and the High Tatra Series sedimentary region. Land — in white, sea — vertically shaded. E — the supposed land of provenance of the exotic fragments (the palaeogeographic map after Książkiewicz, 1956, Fig. 29, simplified)

[1] Lecture delivered by K. B i r k e n m a j e r at the meeting of the Polish Geological Society in Kraków, March 1957.

easily, as it was nearest the Niedzica Series sedimentary region of all the areas emerged in the Dogger in the Outer Carpathians (Fig. 5).

If it was the geanticlinal area north of the Pieniny Klippen Belt basin which originated our fragments, one could expect to find exotic fragments of similar petrographic character transported in a similar way into the Dogger sediments of the Czorsztyn Series. Even, such exotic fragments should be more common there, as the Corsztyn Series sedimentary region was nearer this land than the Niedzica Series sedimentary region.

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Cracow, May, 1958.

B. PETROGRAPHICAL PART

by T. Wieser

The petrogenetic character of the exotic magmatic rocks from Czajakowa Skała is rather monotonous. Only quartz porphyries and acid granitoid rocks are represented among them.

All the exotic fragments from Czajakowa Skała are fairly fresh.

PETROGRAPHICAL CHARACTER OF PORPHYRIES

Among the exotic fragments from Czajakowa Skała the most numerous and interesting are the porphyries. Various structures can be distinguished, and particularly those of the matrix. Using as criterion the structure of the matrix we will subdivide these porphyries into four varieties, namely: microgranitic, micropegmatitic, granophyric, and felsitic porphyries.

Microgranitic Quartz Porphyries

They are all megaphyres, as phenocrysts of feldspar reach one centimeter. The Carlsbad twinnings, visible to the naked eye, are characteristic for the orthoclase. The microscopic observation of the thin plates reveals the presence of plagioclase.

The orthoclase is a cryptoperthite. Its optical character, namely: the extinction angle $\alpha/a = 11^\circ$, $2V = 79^\circ$, implies the presence of a high percentage (up to 40 per cent) of the plagioclase molecules (Tuttle, 1952). Besides the twinned grains, there are many simple grains, particularly in the matrix. Phenocrysts of orthoclase are frequently encircled with more or less wide rims implicatorily intergrown with quartz like myrmekite. Transformation into kaolinite occurs.

Phenocrysts of plagioclase are less frequent. Their rims are similar to those of orthoclase, though they are intergrown not only with quartz but also with orthoclase. Simple plagioclase phenocrysts are rather rare. Usually grains of plagioclase occur in groups composed of individuals with different optical orientation. The presence of polysynthetic albite twins implies their secondary origin as well as their „chess board" nature. The maximum extinction angles indicate that the content of An reaches 28 per cent. Among the transformation processes, calcitization and sericitization are characteristic. The transformation into sericite, however, is more frequent in the plagioclase grains in the matrix, which contain 10 to 20 per cent less An than the plagioclase phenocrysts.

There are also phenocrysts of quartz. Their quantity differs greatly from place to place. The surrounding surfaces of the quartz grains are, as a rule, irregular. This could be explained by the metablastic character of growth, which is indicated by the presence of non-metasomatized relics of feldspars in the external parts of individuals. No lattice deformations of the quartz grains have been observed.

The matrix consists principally of feldspars, i.e. plagioclase and orthoclase, and of quartz and biotite. The structure of the matrix is non-directional and resembles the granitic structure, as plagioclase is more idiomorphic than orthoclase and quartz. The mean diameter of the grains is 0.3 mm. Therefore, it seems that there is a good reason to call the structure of the matrix microgranitic.

The only mafic mineral, biotite, occurred in subordinate quantities. It has been subjected to alterations, and occurs now as pseudomorphous delessite, celadonite or clinochlore. The only accessory minerals observed are the ore minerals and the zircone.

Transitions from the microgranitic porphyries to the granophyres and even to the micropegmatitic porphyries have been observed. The latter is represented by Specimen No 31.

Micropegmatitic Quartz Porphyries

Micropegmatitic quartz porphyries probably resulted from the local chemical differentiation of the porphyric magma in the zones of the concentration of the mineralizators. Such a differentiation can be inferred from the composition of the rock, which consists almost exclusively of orthoclase and of quartz. The orthoclase individuals are thick-tabular and more distinctly idiomorphic than the contacting and intergrowing quartz individuals. The intergrowth is typically graphic. A haematite pigment (a product of the destruction of the ferrosiliceous molecules?) is responsible for the flesh-red colour of the ortoclase. The grains of orthoclase and of quartz are 0.5 to 1.5 mm in diameter.

Granophyric Quartz Porphyries

As in the microgranitic porphyries phenocrysts of orthoclase, oligoclase and quartz occur.

The texture of the phenocrysts of orthoclase is usually identical with that observed in microgranitic porphyries. However, besides Carlsbad twins, rare Baveno twins occur, perthite intergrowth with albite is more distinct (microperthite), and myrmekite-like intergrowths with quartz are more frequent.

Phenocrysts of plagioclase, which seem more common than in the microgranites, occur as simple grains, or, more frequently, as irregularly intergrown individuals. Small phenocrysts, not much greater than the grains of the matrix, are a particularly common form of occurrence of the plagioclase. Another difference from the plagioclase phenocrysts in the microgranites consists in a more idiomorphic shape (subhedral to nearly euhedral). The complex (albite, Carlsbad and Roc Tourné) and polysynthetic (albite) twins have been observed. Injection-antiperthite and myrmekite intergrowths are common. The An content reaches 23 to 25 per cent.

Quartz is not everywhere present in the form of phenocrysts. The grains of quartz are usually fragments of greater individuals which have been crushed (protoclased!). As plagioclase grains, quartz grains in some granophyres are resorbed by the enclosing substance.

The matrix is composed principally of orthoclase and quartz. Mutual graphic intergrowth of the grains of these minerals is usual. Less frequent in the matrix are: albite (up to 5 per cent An), subhehdral, biotite, tabular, completely chloritized, and, sometimes, secondary calcite. Accessory minerals are: zircone, ores, leucoxene, and sphene. The mean diameter of the grains in the matrix is 0.3 to 0.5 mm.

In one specimen, very strongly assimilated fragments of pelite (hornfelsed) gneisses have been found.

Felsophyric Quartz Porphyries

As in the above described porphyries, phenocrysts are composed of orthoclase, plagioclase and quartz. Phenocrysts of orthoclase seem less frequent in relation to the phenocrysts of quartz and of plagioclase than in the above described porphyries. Another difference consists in a greater quantity of Baveno twins in relation to the Carlsbad twins. In one specimen, sieve-like orthoclase has been found. This may point to a rather quick growth, resp. to the metablastic character of growth. Transformations in kaolinite and haematite are frequent.

As in the above described porphyries, groups of polysynthetically twinned (Albite Rule) plagioclase grains occur. Transformations into calcite and sericite have also been observed. Adularization (injection-antiperthite intergrowth) is frequent.

Phenocrysts of quartz are relatively common. Frequently they are fragments of greater grains. The habit of some individuals is distinctly bi-pyramidal. Traces of magma corrosion are common.

Biotite occurred as small laths. It has been completely transformed either into leptochlorite and hydrobiotite associated with calcite and ores, or colourless hydromica only (sericite).

The matrix is fine-felsitic (mean diameter 0.01 mm.), coarse-felsitic (mean diameter 0,08 mm.), or intermediate. It is composed of orthoclase, plagioclase, hydrobiotite. Accessory minerals are: ores, zircone, and apatite.

In some specimens, a taxitic structure accented by the ore pigment is visible.

Enclaves of gneisses with a hornfelsed texture have been observed. The biotite contained in these gneisses has been subjected to the same transformations as in the enclosing rock.

Cinereous Tuffs

Genetically connected with the porphyries were in all probability the cinereous tuffs, represented in the described collection by a single fragment. Its primary vitroclastic microtexture has been altered by crystalization into a felsitic texture. Nevertheless, the characteristic shape of the fragments of vitreous substance has been preserved. In some places in the felsitic mass occur sporadically grains of quartz sand, grains of calcite (pseudomorphs after the crystals of feldspars?), and fragments of the felsitic matrix of the porphyries. Reddish-brown colour of a violet tint is caused by the presence of an irregularly distributed haematite pigment. The colour of the tuffs is somewhat lighter than that of the porphyries.

PETROGRAPHICAL CHARACTER OF GRANITOIDS

The „crystalline basement complex" is represented among the fragments from Czajakowa Skała by gneissoid granites, mica gneisses and aplite. If we use as a criterion the presence of mafic minerals, we can subdivide the gneissoid granites into bi-mica gneissoid granites and biotite gneissoid granites.

Bi-Mica Gneissoid Granites

Their texture is unequigranular and schlieren-like, their structure is panxenoblastic and heteroblastic. The microscopic observations of thin plates reveal numerous symplectic intergrowths. The most important constituents are: plagioclase, orthoclase, quartz, biotite, and muscovite. The last mineral is rare. The only great anhedral grains are formed by oligoclase (24 per cent An). These grains are poikilitically intergrown with biotite, quartz, calcite and muscovite. Intergrowth with quartz is myrmekitic, and sometimes appears throughout the grain. Smaller plagioclase grains are partly sericitized. Grains of orthoclase are frequently intergrown with calcite. Traces of kaolinization of the orthoclase grains are visible. The grains of quartz are, as a rule, granulated, and strong undulatory extinction of light is clearly visible. Grains of biotite are tabular and subhedral. Their absorption colour is dark olive-brown, very intense. The rare presence of muscovite is connected with the stressed zones.

Biotite Gneissoid Granites

They differ from the above described bi-mica gneissoid granites also by a higher degree of cataclasis and by a lower degree of blastesis. The most important feldspar is an oligoclase (20 to 21 per cent An). All the constituents have been subjected to a strong cataclasis, the most strongly quartz. Even the plates of biotite have been split. The fissures in the biotite plates have been filled with calcite as soon as they formed. Also with calcite are filled some greater fissures which cross the whole fragments.

Muscovite Gneiss

It also probably derived from a granite, though rather from an aplitic granite (meta-alaskite) than from a typical granite. Here also some deformations are post-crystalline. The muscovite gneiss is composed of quartz, a basic albite, orthoclase, and of relatively frequent muscovite, transformed by strong deformation and disintegration into the so-called sericite-muscovite. The latter mineral concentrates in the stressed zones in association with feldspar and alternatively with quartz (banded structure). The texture of the rock is cataclastic and gneissoid.

Biotite Augen-Gneiss

It derived from a mica schist. The most conspicuous difference from the other rocks here described is the presence of great metablasts of orthoclase which form the somewhat flattened white or rose anhedral „augen", easily visible to the naked eye. The „augen" of orthoclase are surrounded by a matrix of a schist-like texture, emphasized by the biotite laths. The orthoclase is regularly twinned according to the Carlsbad Law. Its transformations were kaolinization and calcitization.

The grains of oligoclase (An_{20-23}) on contact with the grains of orthoclase are intergrown myrmekite-like with quartz. Other components, e. g. quartz, have been completely granulated, or e. g. the partially chloritized biotite, have been subjected to various elastic deformations or even to disintegration. The texture of the rock is blastomylonitic. The structure is lenticular.

Aplite

Aplite is the only rock of the basement which has been subjected but to a low-grade metamorphosis. Is is composed of orthoclase, of a basic albite, and of quartz. The strongly chloritized biotite is sporadic. The rock is unequigranular, as the non-twinned grains of orthoclase are somewhat greater than other grains. Myrmekite intergrowths are frequent in plagioclases; lamellar albite twinnings occur but very rarely.

Cataclasis can be observed, particularly in the grains of quartz. After the cataclasis the aplite has been strongly impregnated with, and even metasomatized by, calcite.

GENERAL REMARKS AND COMPARISONS

The fairly constant mineral composition of the above described porphyries, and particularly the uniform chemism of the orthoclase cryptoperthites, would be sufficient to prove the comagmatism of all these rocks. The rather great differences in texture could be connected with various conditions of the crystallization, even if it were in the same magmatic body. Generally speaking, the microgranitic and granophyric textures preponderate in the intruding part of a magmatic body, and also in the interior of its extrusive part, and the felsitic texture is connected with small extrusions or with the peripheral parts of subvolcanic injections or of great extrusions. The presence of a fragment of a porphyry tuff implies the existence of effusions of porphyric lavas.

That the only xenoliths found in the porphyries are composed of the pelite gneisses seems to indicate that these gneisses played an important rôle among the rocks which surrounded the intrusions. The pelite gneisses belong probably to the intruded „cristalline basement".

The character of the above described gneisses and of the aplite, and particularly the preponderance of cataclastic and blastomylonitic structures, seem to indicate that these rocks derived from the apical part of a granitoid batholith. That no other rocks of the crystalline basement are represented among the fragments from Czajakowa Skała seems to inricate that the erosion did not reach the deeper parts of the batholith.

Exotic fragments of porphyritic rocks are also known from the Upper Cretaceous and Palaeogene deposits in the Pieniny Klippen Belt in Poland (Wieser, 1958). The difference from the porphyries described in the present paper is conspicuous. The only common feature is the preponderance of the orthoclase over the plagioclase, which permits to classify both as rhyolitic porphyries. No cinereous tuffs and micropegmatites have been found in the Upper Cretaceous and Palaeogene deposits in the Pieniny Klippen Belt in Poland. On the other hand, fragments of deep-seated rocks somewhat similar to those described in the present paper have been found. This resemblance, however, is not very important.

Exotic fragments of granophyres, which are easy to correlate, have already been often described from the Carpathians. According to A. Gaweł (1932) they occur in the Krosno Beds. As in these granophyres biotite is common and plagioclase contains $An_{35.5}$, they could not have been comagmatic with our granophyres. Also, the granophyres found in the Istebna Beds and described by the present author (1950) could not have been comagmatic with granophyres described in the present paper.

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Warsaw, May 1957.

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EXPLANATION OF PLATES

Plate VIII

Fig. 1. Microgranitic quartz porphyry. The phenocryst of orthoclase in the upper part is surrounded by a wide rim implicatorily (sieve-like) intergrown with quartz. × 12. Crossed nicols. Specimen No 1

Fig. 2. Contact of the microgranitic quartz porphyry (upper left) with the micropegmatitic orthoclase quartz porphyry. × 13. Crossed nicols. Specimen No 31

Plate IX

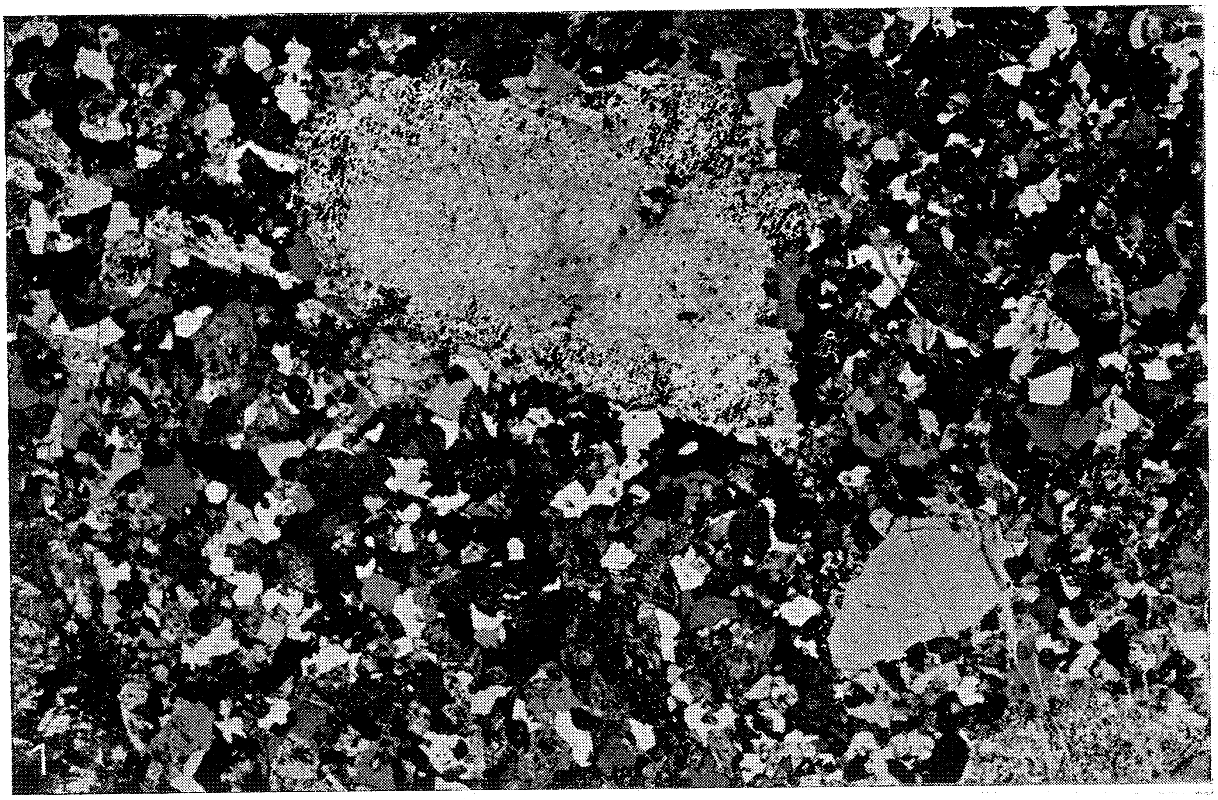
Fig. 1. Granophyric quartz porphyry with rare phenocrysts of plagioclase. × 15. Crossed nicols. Specimen No 18

Fig. 2. Felsophyric quartz porphyry. Fissured and partly corroded phenocrysts of quartz and of feldspars are visible. × 10. Crossed nicols. Specimen No 6

Plate X

Fig. 1. Cinereous tuff with a vitroclastic texture. A fragment of the matrix of a porphyry is visible on the right. The size of the fragment is that of a grain in a „volcanic sand". × 15. Nicols parallel. Specimen No 7

Fig. 2. Biotite augen-gneiss. A great metablast of orthoclase in the middle. × 8. Crossed nicols. Specimen No 13



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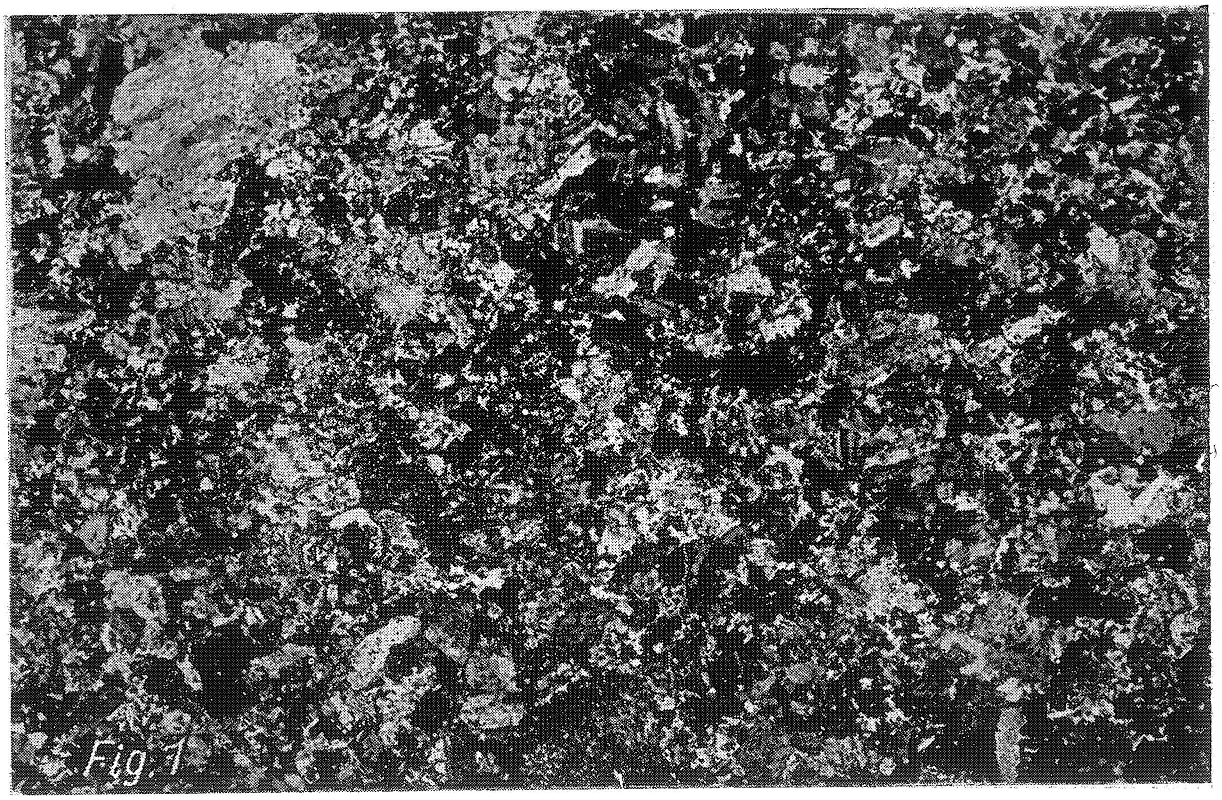

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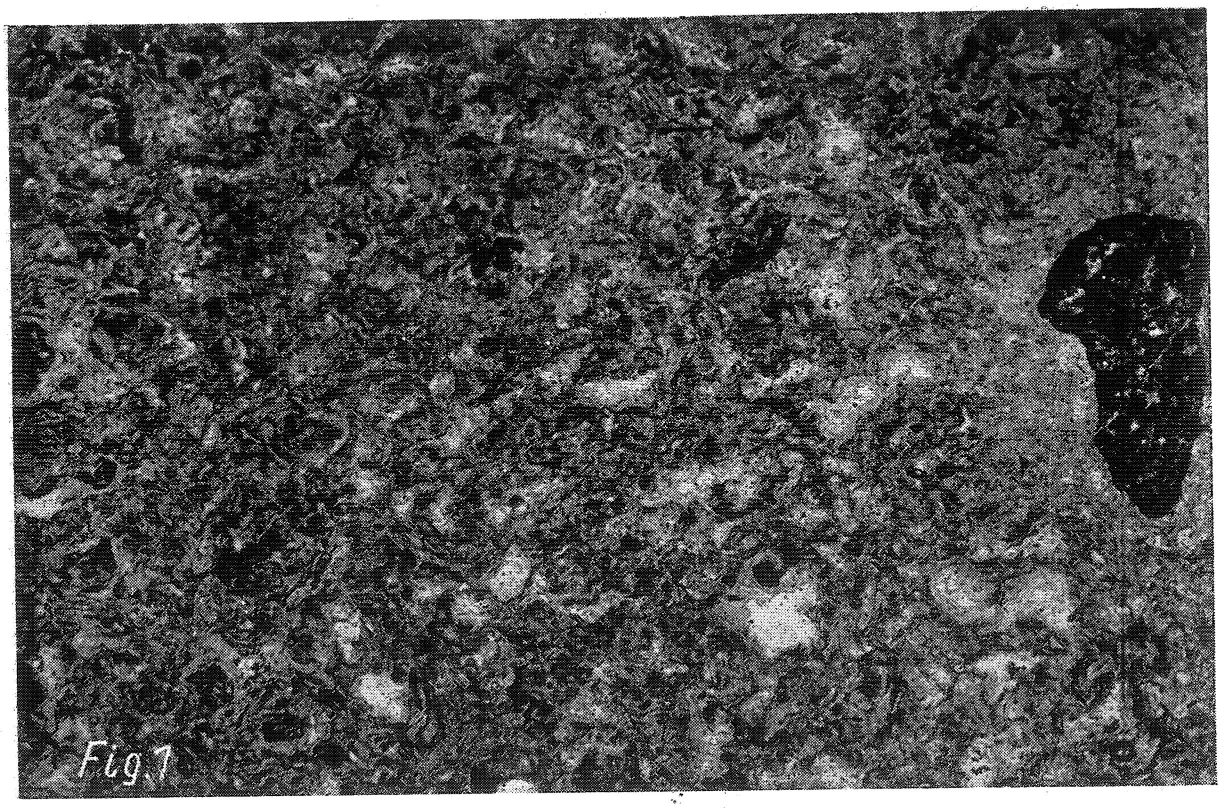

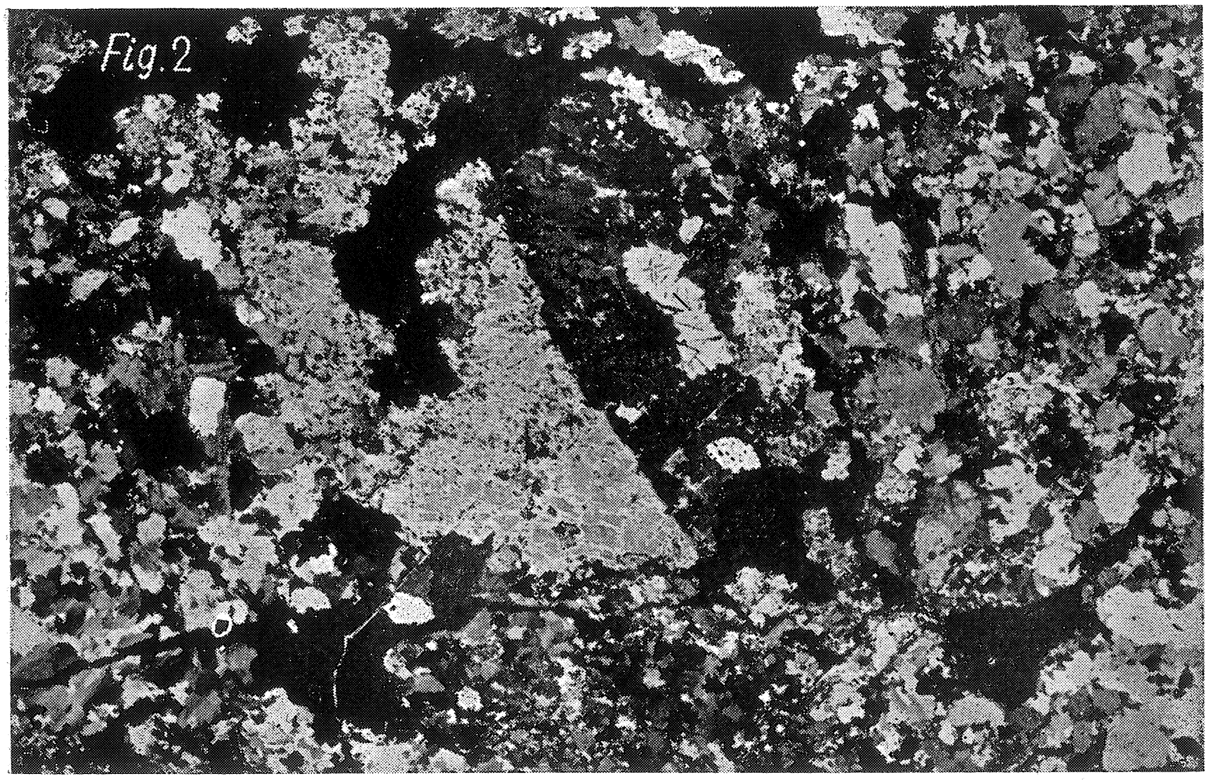

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