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MARIAN KAMIEŃSKI, CZESŁAW PESZAT, JACEK RUTKOWSKI

ZMIENNOŚĆ PETROGRAFICZNA PIASKOWCÓW KARPACKICH I ZAGADNIENIE ICH KLASYFIKACJI

(4 fig.)

Petrographic variability of Carpathian sandstones and the problem of sandstone classification

(4 Figs.)

STRESZCZENIE

Wstępne badania petrograficzne piaskowców godulskich, istebniańskich, magurskich oraz piaskowców fliszu podhalańskiego wykonane w Katedrze Złóż Surowców Skalnych AGH wykazały, że ich jakościowy skład mineralny bez względu na poziom stratygraficzno-facjalny i obszar występowania jest do siebie zbliżony. Zmusza to do badań ilościowych, które stanowią podstawę petrograficznej klasyfikacji piaskowców. Zagadnienie to zostało potraktowane bardzo szeroko w literaturze omówionej między innymi przez M. Turnau-Morawską (1957), G. Kleina (1963) i W. D. Szutowa (1965). Piaskowce karpackie w świetle wykonanych badań (około 500 analiz planimetrycznych) odznaczają się zmiennością w ilości poszczególnych składników. Dotyczy to nie tylko piaskowców pochodzących z danego poziomu stratygraficzno-facjalnego (fig. 2, 3, 4), ale także próbek z tego samego odsłonięcia, a nawet w pewnym stopniu z jednej i tej samej ławicy (fig. 1), które często znajdują się w dwóch sąsiadujących ze sobą polach trójkąta projekcyjnego, reprezentujących różne odmiany piaskowców.

Zmienność w obrębie poszczególnych ławic wiąże się w znacznym stopniu z wielkością ziarna materiału klastycznego. Ilość okruchów skał obcych jest na ogół wyższa w próbkach gruboziarnistych niż w drobnoziarnistych, bowiem w tych ostatnich uległy one dezintegracji. Odwrotnie zachowują się glaukonit, łyszczyki i spoiwo, których ilość zazwyczaj wzrasta w miarę zmniejszania się wielkości ziarna. Związane z tym ilościowe zmiany składu mineralnego mogą być rzędu kilku, a nawet kilkunastu procent. Powoduje to, że piaskowce gruboziarniste posiadają zazwyczaj bardziej szarogłazowy charakter, a drobnoziarniste są bardziej kwarcowe. Uwydatnia się to szczególnie dobrze w przypadku warstwowania frakcjonalnego. Przy normalnym warstwowaniu frakcjonalnym próbki ze spągowej części ławicy są wzbogacone w okruchy skał obcych, a więc z tego tytułu przybierają bardziej szarogłazowy charakter.

W związku z przedstawioną zmiennością podział trójkąta projekcyjnego na liczne, a tym samym bardzo wąskie pola mające przedstawiać różnego rodzaju odmiany piaskowców, jak to czynią niektórzy autorzy, wydaje się mało uzasadniony. Stąd też w pracy zastosowano stosunkowo prosty podział M. Turnau-Morawskiej (1957), który został nieco zmodyfikowany (fig. 1).

W zastosowanej klasyfikacji piaskowce z poziomu dolnego warstw godulskich stanowią najczęściej piaskowce oligomiktyczne i kwarcowe, rzadziej szarogłazowe (fig. 2). W poziomie środkowym są to zazwyczaj piaskowce szarogłazowe, rzadziej arkozowe, oligomiktyczne i szarogłazy. Typowe piaskowce górnogodulskie reprezentują piaskowce oligomiktyczne, rzadziej arkozowe i szarogłazowe, wyjątkowo kwarcowe. Odrębny charakter mają gruboławicowe i gruboziarniste piaskowce tworzące w Beskidzie Śląskim wkładki w najwyższej części górnych warstw godulskich, reprezentujące szarogłazy i piaskowce szarogłazowe. Piaskowce istebniańskie znajdują się w polach piaskowców arkozowych, oligomiktycznych i szarogłazowych (fig. 3). Piaskowce trzeciorzędowe posiadają na ogół podobny charakter jak piaskowce środkowogodulskie. Piaskowce magurskie stanowią najczęściej piaskowce szarogłazowe, w mniejszym stopniu arkozowe. Znacznie rzadziej występują tutaj piaskowce oligomiktyczne, szarogłazy i arkozy (fig. 4). Piaskowce fliszu podhalańskiego stanowią piaskowce szarogłazowe, rzadziej szarogłazy (J. Bromowicz, Z. Rowiński, 1965).

Wśród badanych piaskowców Karpat fliszowych najczęściej reprezentowane są piaskowce szarogłazowe, stanowiące 39% uwzględnionych próbek, w mniejszym stopniu piaskowce oligomiktyczne (26%) i arkozowe (24%). Rzadziej i tylko w niektórych seriach występują szarogłazy (6%) i piaskowce kwarcowe (4%), a sporadycznie arkozy (1%).

Na tle przeprowadzonych badań należy stwierdzić, że określenie charakteru i zmienności piaskowców fliszowych musi się opierać na licznych próbkach. Winny być one pobierane z uwzględnieniem zmian uziarnienia w obrębie poszczególnych ławic, kierunków z jakich materiał klastyczny był dostarczany do zbiornika sedymentacyjnego oraz procesów dia- i epigenezy.

Katedra Złóż Surowców Skalnych
Akademii Górniczo-Hutniczej
w Krakowie

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Abstract. In the present study, the variability in mineral composition of some sandstones from the Polish Flysch Carpathians is discussed, together with the problem of their classification. This variability is sometimes very marked, becoming conspicuous in particular stratigraphic and facies horizons and even within single beds. Although such variability calls for the application of a relatively simple petrographic classification, sandstones from the same stratigraphic and facies horizon usually occur in several fields, representing different petrographies. Furthermore, samples from one and the same bed may represent different types of sandstone. This arises from changes in grain-size, caused by the existence of graded bedding. In the Polish Flysch Carpathians, greywacke — sandstones predominate, and to a lesser extent, oligomictic and arkosic sandstones occur. Greywackes and quartz sandstones are found more rarely, and arkoses seldom occur.

INTRODUCTION

In this preliminary study, attention is drawn to only one problem of the lithology of the Carpathian sandstones, namely that of their variability, and connected with this, the problem of their classification. The discussion is based on around 500 planimetric analyses carried out in the Department of Non- Metallic Mineral Deposits, Academy of Mining and Metallurgy, Kraków. Here the following are considered: the Godula Sandstones (Turonian — Lower Senonian), the Istebna Sandstones (Senonian — Paleocene), the Magura Sandstone (Eocene) and the Podhale Flysch sandstones (Eocene). The stratigraphic position of the Carpathian sandstones are discussed by F. Bieda et al. (1963). Problems of the palaeogeography and sedimentation of the sandstones are considered by M. Książkiewicz, in a 1960 paper and with other authors in the Stratigraphic and Facies Atlas of the Carpathians, edited by the last-mentioned author (1962), and also by R. Unrug (1963).

Samples of the sandstones investigated came exclusively from the western part of the Polish Flysch Carpathians. The greatest number of samples investigated (185) came from the Godula Sandstones. Sandstones of the Lower Godula Beds horizon (70 samples) were sampled in the Bielsko-Biała region (Wisła, Obłaziec, Czantoria, Straconka) at Porąbka as well as at Zagórnik and Rzyki near Wadowice. Sandstones from the middle horizon of the Godula Beds (80 samples) were selected for sampling in the Bielsko region (Brenna and Szyndzielnia), in the Wadowice region (Rzyki, Barwałd, Sułkowice) at Wierzbanowa, near Myślenice, and at Bieśnik, near Czchów. Samples (40 in all) of typical Upper Godula sandstones were taken in the stream Gołaszowski (Bielsko region), as well as in the Wadowice area (Mucharz and Sułkowice).

Samples of the Istebna Sandstones (140 samples) were collected in the regions of Bielsko (Wisła Głębce, Istebna, Straconka), Żywiec (Kamesznica), Wadowice (Mucharz, Kalwaria, Sułkowice), Myślenice (Droginia), Bochnia (Wiśnicz, Królówka, Muchówka, Sobolów, Lipnica) and Czchów (Czchów, Melsztyn, Charzewice). The Istebna Sandstones from the Bochnia and Czchów regions are considered on the basis of samples described by K. Skoczylas-Ciszewska and M. Kamieński (1959).

The Magura Sandstone is represented by 160 samples taken from the region of Żywiec (Korbielów), Myślenice (Lubień and Tenczyn), Limanowa, as well as Nowy Sącz (Klęczany, Kamionka, Wierchomla). Here also the results of studies made by S. Siliwończuk (1965) in Kamionka, near Nowy Sącz, are utilised. Podhale Flysch sandstones of the Nowy Targ region are described after J. Bromowicz and Z. Rowiński (1965).

The qualitative mineralogical compositions of Carpathian sandstones, irrespective of stratigraphic and facies horizon or locality, are, as a rule, similar. This is particularly true for quartz, feldspars, micas and glauconite, and to a lesser degree for rock fragments and cement. The cement of Carpathian sandstones is fairly variable, both in composition and in the amount present. It is necessary to emphasize, however, that certain types of cement are characteristic for particular series. Among the components of the cement, strongly crushed, fragmental material, with diameters less than 0.01 mm. („matrix") should be mentioned. Silica is another component of the cement, occurring in the form of microgranular aggregates of quartz, quartz-chalcedony or chalcedony-opal, and also being developed as minute regeneration rims. A common constituent of the cement is calcium carbonate, recrystallized to a very variable degree. This either fills the voids between the grains or forms the bulk of the rock. To a markedly lesser degree, chloritic material, glauconite and iron compounds, which usually play the rôle of colouring pigments within the rocks, occur as cement components. The cement constituents mentioned seldom occur separately, and are usually seen in varying proportions. Thus the cement of Carpathian sandstones also possess a polymineralic character. The amount of cement present is very variable and within the limits of particular beds sometimes fluctuates widely. This factor is related to the conditions of sedimentation as well as to diagenetic and epigenetic changes. As a result of the latter, fragments of limestone sometimes undergo recrystallization and grains of quartz and feldspar are resorbed, thus enriching the cement.

The qualitative study of mineralogical composition does not generally lead to the same kind of results as those arising from quantitative work, upon which latter rest the petrographic classifications of sandstones. The problem of a genetic classification of sandstones has been widely discussed in geological literature (e. g. K. Łydka 1955, M. Turnau-Morawska 1957, G. Klein 1963, E. F. McBride 1963, R. H. Dott 1964, V. D. Shutov 1965, G. N. Brovkov and A. E. Mogilev 1965). In the majority of studies, authors show variability in mineralogical composition of sandstones on a triangular projection. The constituents located at the vertictes of the triangles, as well as the boundaries of the fields adopted for particular varieties of sandstone, are very variable.

An investigation of mineralogical composition shows that the Carpathian sandstones are generally characterized by a great variability in the proportions of particular constituents, frequently seen as a scattering of projection points over a considerable part of the triangle. This is shown not only by sandstones from a given stratigraphic and facies horizon (Fig. 2, 3, 4), but also samples from the same exposure, and to a certain degree, even from one and the same bed. In Fig. 1, the last-mentioned type of variability is shown for material representing different sandstone series. The separate points indicating samples taken from the very same bed are joined by lines. Variability within a bed may be fairly marked, and this phenomenon is seen in all the sandstone series investigated.

The variability of mineralogical composition in particular sandstone beds is to a marked degree related to the sizes of the clastic mineral grains. First and foremost, this concerns fragments of exotic rocks, the proportion of which is generally higher in coarse-grained samples than in those which are made up of fine grains. It is a proven fact that in the fine fraction, fragments of exotic rocks are mainly seen as their disintegration products, monomineralic constituents. On the other hand, the amounts of glauconite, micas and cement usually increase in proportion to a decrease in the size of the clastic material. In connection with this last point, the quantitative differences in mineralogical composition may be in the order of several or even a dozen or more percent. This means that samples of coarse-grained sandstone have the character of greywacke-sandstone, while those of fine grain-size are more quartzose. This is particularly conspicuous in the case of beds showing graded bedding, a characteristic feature of flysch sandstones. It should here be mentioned that attention has already been called to the relationship between mineralogical composition and grain-size by, for instance, G. Fischer (1934).

The existence of this type of variation in mineralogical composition within particular beds and also within stratigraphic and facies units has great significance for the classification of sandstones. Furthermore, the division of the projection triangle into numerous, narrow fields to represent different types of sandstones appears to be artificial and poorly substantiated. Thus as a basis for further considerations, the relatively simple classification scheme of M. Turnau-Morawska (1957) is used in the present study, with only slight ammendments (Fig. 1). M. Turnau-Morawska's quartz-sandstone (loc. cit.) included rocks with more than 80% quartz, while here the term is restricted to sandstones with more than 90% of this constituent. Here also rocks containing 80—90% quartz are

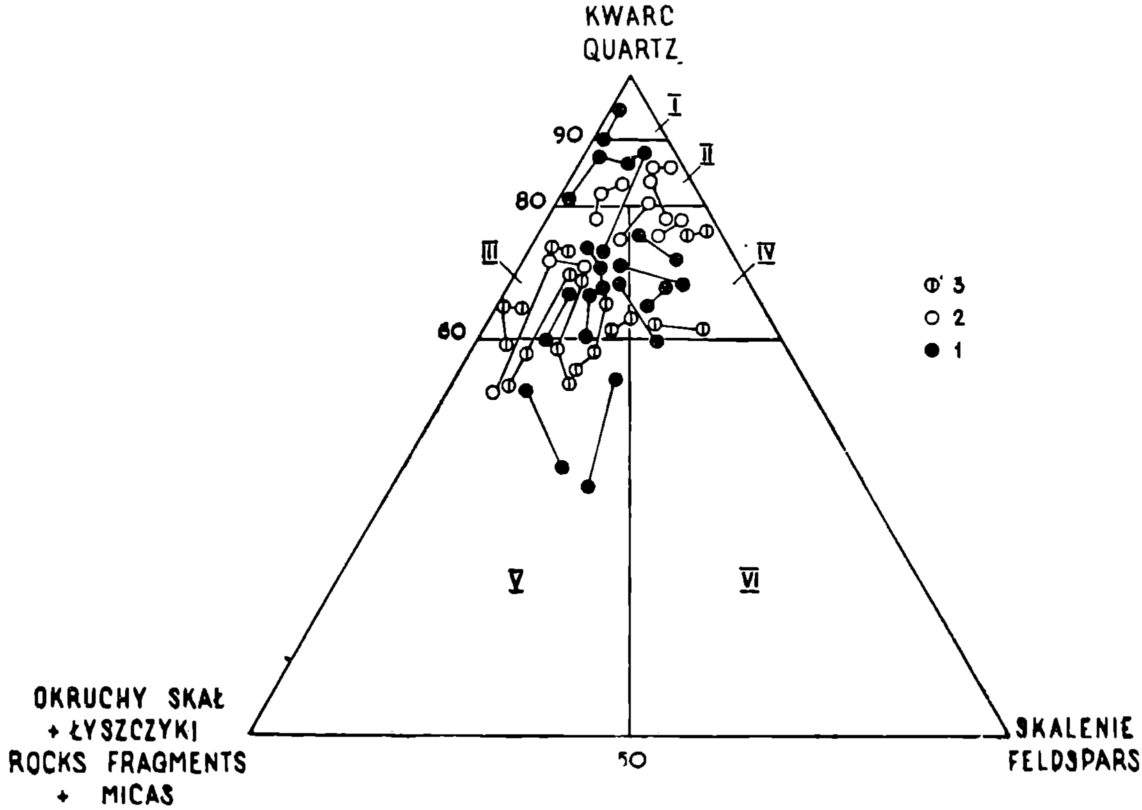

Fig. 1. Zmienność składu mineralnego w obrębie poszczególnych ławic piaskowców na tle trójkąta klasyfikacyjnego stosowanego w pracy: 1 — piaskowce godulskie; 2 — piaskowce istebniańskie; 3 — piaskowce magurskie. Liniami połączono punkty odpowiadające próbkom pochodzącym z jednej i tej samej ławicy: I — piaskowce kwarcowe; II — piaskowce oligomiktyczne; III — piaskowce szarogłazowe; IV — piaskowce arkozowe; V — szarogłazy; VI — arkozy

Fig. 1. Variability in mineralogical composition in the lower parts of particular sandstone beds, shown on the classification triangle adopted in the present study: 1 — Godula Sandstone; 2 — Istebna Sandstone; 3 — Magura Sandstone. Lines joining points indicate samples coming from the same bed. I — quartz-sandstones; II — oligomictic sandstones; III — greywacke-sandstones; IV — arkosic sandstones; V — greywackes; VI — arkoses

termed oligomictic sandstones. In spite of this simplification in subdivision, samples collected by the authors from one bed frequently occur in two neighbouring fields of the triangular projection, representing different types of sandstone.

TERMINOLOGY OF THE SANDSTONES DISCUSSED

The greatest number of samples investigated by the authors from among the previously mentioned Carpathian sandstones came from the Godula Beds. The variability in mineralogical composition of the three horizons here distinguished is shown in Fig. 2. The sandstones from the lower horizon have the highest quartz content, as well as the lowest amounts of feldspar, exotic rock fragments and micas. Their projection points are in the oligomictic and quartzose sandstone fields, and rarely in that of the greywacke-sandstones. The sandstones from the middle horizon have a lower and more variable quartz content, and more rock fragments and micas. These are mainly greywacke-sandstones, rarely arkosic sandstones, oligomictic sandstones and greywackes. The typical

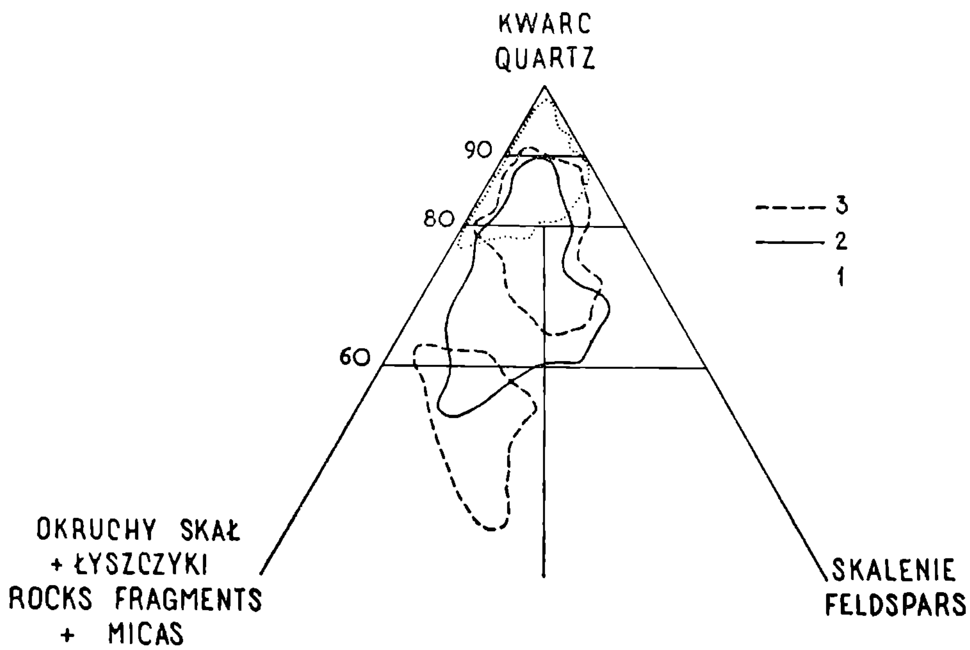

Fig. 2. Zmienność piaskowców godulskich: 1 — poziom dolny; 2 — poziom środkowy; 3 — poziom górny

Fig. 2. Variability in the Godula Sandstone: 1 — Lower Horizon, 2 — Middle Horizon, 3 — Upper Horizon

Upper Godula sandstones are characterized by a somewhat higher and less variable quartz content and usually represent oligomictic sandstones, rarely arkosic sandstones and greywacke-sandstones, and seldom quartz--sandstones. The thick-bedded and coarse-grained sandstones forming intercalations in the uppermost par of the Upper Godula Beds display a variable character. These rocks (6 samples), exposed in the stream Gołaszowski (near Bielsko), occupy a separate field in the triangle, comprising exclusively greywackes and greywacke-sandstones.

Within the Istebna Sandstones, which rest stratigraphically upon the Godula Beds, upper and lower levels are distinguished. The samples investigated preliminarily by the authors, representing both of these horizons, show no great differences in petrographic composition and thus appear together on the graph (Fig. 3). By comparison with the Godula Sandstones, they have a somewhat lower quartz content and their projection points occur in the fields of arkosic sandstones, oligomictic sandstones and greywacke-sandstones. It may also be mentioned that the field in which the Istebna Sandstones appear occupies the axial part of the triangle.

The Tertiary sandstones investigated displayed in the triangular projection a character similar to that of the Middle Godula Sandstone. The Magura Sandstone showed a variable quartz content and is represented by projection points most frequently found in the greywacke-sandstone field, and to a lesser degree in the arkosic sandstone field (Fig. 4). Markedly more rarely found are oligomictic sandstones, greywackes and arkoses. The Magura Sandstone of Babia Góra was the subject of petrographic investigations by T. Wieser (1963, 1966). This author employed

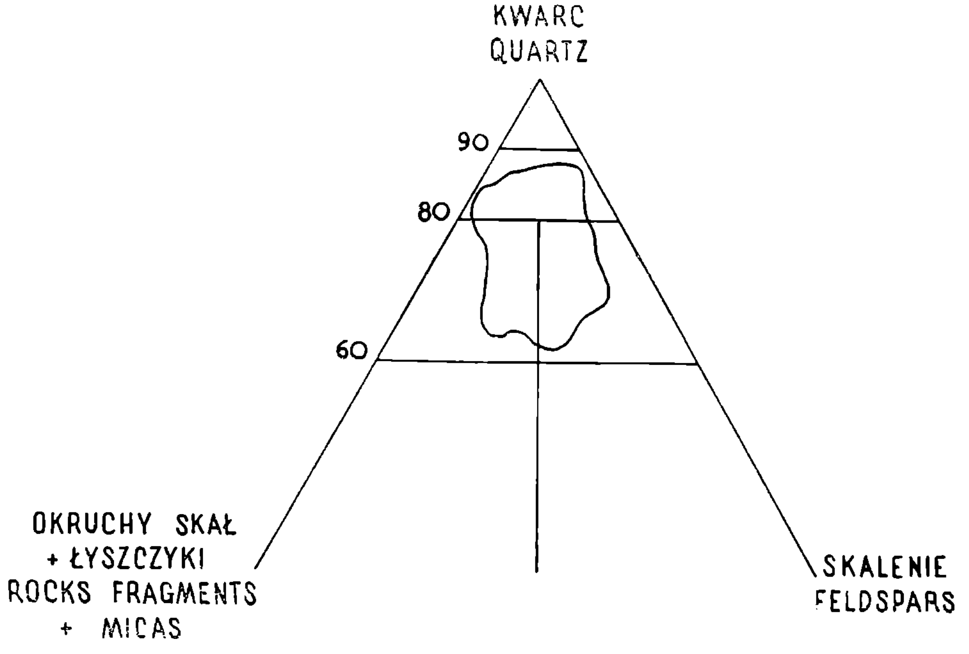

Fig. 3. Zmienność piaskowców istebniańskich
Fig. 3. Variability in the Istebna Sandstone

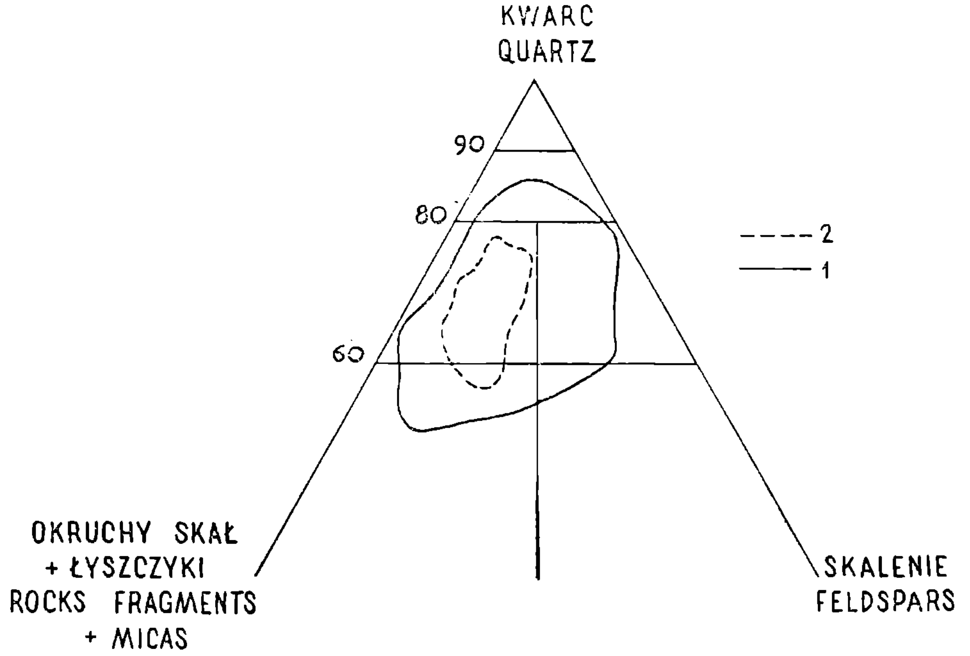

Fig. 4. Zmienność niektórych piaskowców paleogeńskich: 1 — piaskowce magurskie; 2 — piaskowce fliszu podhalańskiego
Fig. 4. Variability in some Palaeogene sandstones: 1 — Magura Sandstone; 2 — sandstones from the Podhale Flysch

the triangular projection of C. Gilbert (H. Williams, F. Turner, C. Gilbert 1954) and his results are not at variance with those obtained in the present study.

The Podhale Flysch sandstones are considered on the basis of the work of J. Bromowicz and Z. Rowiński (1965). These rocks show a markedly smaller variation in mineralogical composition. Their projection points lie in the field of greywacke-sandstones and only in insignificant numbers enter the greywacke field.

A. Ślączka and R. Unrug (1966) used a triangular projection similar to the one employed in the present study (Fig. 1), but subdivided the triangle in a somewhat different manner. The study made by the last-mentioned authors dealt with some Eocene-Oligocene sandstones from the eastern part of the Polish Carpathians. The small number of samples from the particular horizons studied by these authors does not, however, permit a broad comparison with the material described in the present study. It is only possible to remark that in the classification scheme used in the present account, the Mszanka Sandstone represents oligomictic and quartz-sandstones, while the Cergowa Sandstone is found in the greywacke and greywacke-sandstone fields. The Kliwa Sandstone comprises quartz-sandstones, oligomictic sandstones, greywacke-sandstones and greywackes. The sandstones from the Menilitic Shales are quartz-sandstones.

CONCLUDING REMARKS

From the descriptions of these preliminary investigations, it is seen that within particular stratigraphic and facies horizons of the Carpathian sandstones, a variability in mineralogical composition is found, which as shown in the triangular projections included, is between 20—35%. This means that sandstones from the very same horizon, in spite of the use of a relatively simple classification scheme, generally occur within the boundaries of three, and sometimes even four or five fields representing different types of sandstone. This variability is marked, as mentioned above, within particular beds, especially in the case of graded bedding. With normal graded bedding, samples taken from the basal part of the bed are enriched in fragments of exotic rocks, and thus have a character more approaching that of greywackes.

On the basis of work carried out up to the present time, it may be concluded in the Polish Flysch Carpathians, following the classification adopted, greywacke-sandstones are most frequently represented, comprising 39% of the samples investigated. Oligomictic sandstones (26%) and arkosic sandstones (24%) occur more rarely. Greywackes (6%) and quartz-sandstones (4%) are decidedly rare, only occurring in certain series. Samples with the character of arkoses (1%) occur quite sporadically.

It should also be stated that the definition of the character and variability of flysch sandstones, and also of other sandstones derived in the course of intensive erosion and orogenic movements, must be based on numerous samples. These must be selected so as to take into account changes in grain properties within particular beds, the direction from which clastic material was supplied to the sedimentary basin, as well as diagenetic and epigenetic processes.

Tranlated by
B. Marszał and F. Simpson

Department of Non-Metallic Mineral Deposits,
Academy of Mining and Metallurgy
Kraków

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