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Roman CHLEBOWSKI

Institute of Geochemistry,
Mineralogy and Petrography
Warsaw University
Żwirki i Wigury 93
02-089 Warszawa, POLAND

Mineralogical description of sandur deposits from the forefield of the Renard Glacier (Wedel Jarlsberg Land, Spitsbergen) on the ground of heavy minerals

ABSTRACT: Heavy minerals in sandur deposits from the forefield of the Renard Glacier were investigated. They are concentrated only in fractions below 0.1 mm in diameter. Composition and preservation of heavy minerals indicate very high dynamic in the sedimentary environment.

Most resistant minerals as zircon and tourmaline predominate and are strongly crumbled. They probably may serve as mineral indicators of sandur deposits. If distinguished regularities are confirmed in forefield in other Spitsbergen sandurs, then contemporary and Pleistocene sandur deposits could be compared. No mineralogic differentiation of intra- and extramorainal sandurs was noted.

Key words: Arctic, Spitsbergen, mineralogy, sandur deposits.

Introduction

Contemporary sandurs in Spitsbergen and Iceland, and their relationships to the Pleistocene ones were investigated mainly from geomorphologic, sedimentologic and structural points of view (Klimek 1972, Bogacki 1976). Dynamics of glacial waters and their influence on transport and deposition of clastic material were also studied. During geomorphological research works intra- and extramorainal sandurs were distinguished and mapped (Flood, Nagy and Winsnes 1971, Szczęsny *et al.* 1989). However no mineralogic criteria existed so far for such discrimination and it has been therefore the author's task to find them out.

Samples were collected from sandurs in the forefield of the Renard Glacier (Renardbreen) in summer 1988 during the 3rd Polar Expedition organized by the Maria Curie-Skłodowska University of Lublin. Similar investigations of sandur deposits from the forefield of the Scott Glacier (Scottbreen) will be presented in the next publication.

Studied area

Sandurs in the forefield of the Renard Glacier are the biggest in the northwestern Wedel Jarlsberg Land (Fig. 1). Their dynamics of sedimentation was studied previously (Łanczont 1988) but mineralogic features seem also

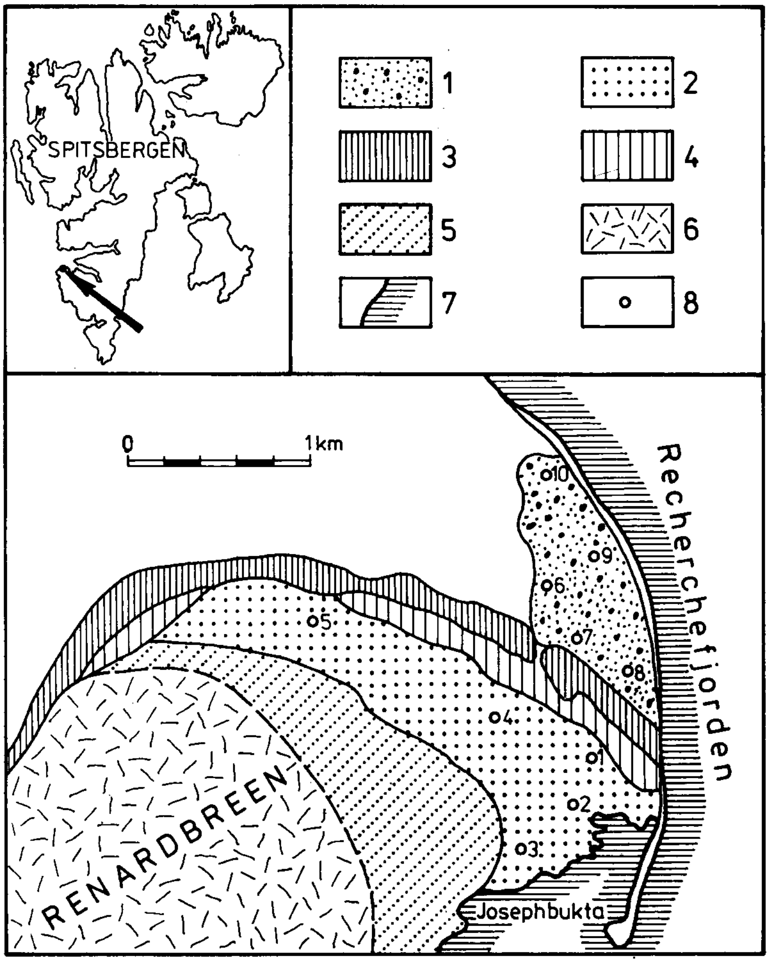

Fig. 1. Morphodynamic zones of the Renard Glacier forefield (Pękala and Repelewska-Pękalowa 1988). 1 — extramorainal sandur, 2 — intramorainal sandur, 3 — terminal and lateral moraines, 4 — terminal ice-cored moraine, 5 — contemporaneous sandur with icings, 6 — core samples

interesting due to quick retreat of the Renard Glacier during the last dozens of years (Pękala 1987) resulting in intensive sandur deposition.

Morainic material, as well as lateral and terminal moraines of this glacier contain the surrounding rock pieces from mountains. Lithology of rock debris is considerably warying as mountain massif in this area are composed of Precambrian metamorphic rocks: mainly tillites, quartzites, phyllites and carbonates (Flood, Nagy and Winsnes 1971). Mineralogical differentiation of these massif, accompanied by complex tectonics and periglacial processes generate very intensive physical weathering what makes the Renard Glacier by intensively supplied with weathering waste. Glacier melt waters favor impetous transport of the waste material. Transport distance is very short and almost all caried material is deposited near the glacier. Only the finest clay particles are washed away into the fiord. Meltwaters form shallow river beds which combine into two streams. This environment indicates very high dynamics, especially during intensive glacial ablation. When the amount and sizes of transported rock pieces are the greatest (*cf.* Klimek 1972).

The waste from mountain slopes, moraine ramparts and morainic debris are crushed during dragging. Rock pieces are not rounded and are badly sorted. Grain size and microscopic observations indicate that such features are typical in all the sizes, from boulders to aleurites. Consequences of impetous and short transport in composition of heavy minerals in sandur deposits are presented in this paper.

Composition of heavy minerals and its interpretation

Heavy minerals were analysed in all the collected samples (Fig. 1). The latter were preliminary subdivided into separate fractions: above 1.0, 1.0—0.5, 0.5—0.25, 0.25—0.1, 0.1—0.05 and below 0.05 mm. The coarse fractions (above 1.0 and 1.0—0.5 mm) do not contain only heavy minerals but they are composed of iron oxides, carbonate and Fe — chloritic aggregates, and of carbonate splinters. Within the fraction 0.5—0.25 mm there are mainly Fe-chloritic, carbonate — chloritic and carbonate aggregates, only but also individual biotite plates. Within the fraction 0.25—0.1 mm Fe-chloritic, carbonate chloritic and Fe-oxide aggregates and chlorite-clay minerals are accompanied by heavy minerals including zirkon, tourmaline, biotite and chlorite. Tourmaline is the most frequent among all the mentioned transparent heavy minerals. The other two or three minerals are rare or even absent in some samples. Within the fractions 0.1—0.05 and below 0.05 mm heavy minerals are the most common and therefore only for them the proportions of heavy minerals, were calculated (Table 1).

Table 1

Contents proportion of transparent heavy minerals in samples of sandur deposits from the forefield of Renard Glacier

Nos. of samples	Fraction in mm	Transparent heavy minerals (in %)									
		Zirkon	Tourma-line	Epidote	Amphi-boles	Biotite	Chlorite	Kyanite	Rutile	Anatase	Staurolite
1	< 0.05	90.0	3.0	1.0	1.0	2.5	1.0	—	1.0	0.5	—
	0.05—0.1	64.0	36.0	—	—	—	—	—	—	—	—
	0.1 —0.25	—	trace	—	—	trace	trace	—	—	—	—
	0.25—0.5	—	—	—	—	—	—	—	—	—	—
2	< 0.05	97.0	1.0	trace	trace	—	—	—	—	1.0	trace
	0.05—0.1	62.0	31.0	3.0	0.5	2.5	—	—	—	—	0.5
	0.1 —0.25	—	trace	—	—	trace	trace	—	—	—	—
	0.25—0.5	—	—	—	—	—	trace	—	—	—	—
3	< 0.05	94.0	2.0	0.5	1.0	trace	—	—	trace	1.0	1.0
	0.05—0.1	82.0	16.0	0.5	—	—	1.5	—	—	—	—
	0.1 —0.25	—	trace	—	—	trace	trace	—	—	—	—
	0.25—0.5	—	—	—	—	—	—	—	—	—	—
4	< 0.05	90.0	7.0	—	—	—	—	—	—	—	3.0
	0.05—0.1	57.0	31.0	—	—	—	9.0	—	3.0	—	—
	0.1 —0.25	—	—	—	—	—	trace	—	—	—	—
	0.25—0.5	—	—	—	—	—	—	—	—	—	—
5	< 0.05	96.0	1.5	trace	trace	trace	—	—	0.5	0.5	—
	0.05—0.1	60.0	38.0	—	—	—	1.5	—	0.5	—	—
	0.1 —0.25	—	trace	—	—	trace	trace	—	—	—	—
	0.25—0.5	—	—	—	—	—	—	—	—	—	—
6	< 0.05	89.0	7.0	—	—	0.5	—	trace	1.5	1.5	—
	0.05—0.1	69.0	25.0	—	0.5	2.0	3.0	—	—	0.5	—
	0.1 —0.25	—	trace	—	—	—	trace	—	—	—	—
	0.25—0.5	—	—	—	—	—	—	—	—	—	—

7	< 0.05	96.0	2.0	trace	—	—	trace	—	—	1.0	—
	0.05—0.1	87.0	10.0	—	—	1.5	—	—	—	1.5	—
	0.1 —0.25	trace	trace	—	—	trace	—	—	—	—	—
	0.25—0.5	—	—	—	—	—	trace	—	—	—	—
8	< 0.05	89.0	3.0	3.0	1.5	1.0	—	1.0	0.5	trace	—
	0.05—0.1	91.0	5.0	0.3	trace	0.5	0.5	0.5	0.5	1.0	0.5
	0.1 —0.25	trace	trace	—	—	—	—	—	—	—	—
	0.25—0.5	trace	trace	—	—	trace	—	—	—	—	—
9	< 0.05	92.0	4.0	1.0	—	—	1.0	—	1.0	1.0	—
	0.05—0.1	62.0	25.0	—	—	1.5	8.0	0.5	0.5	0.5	—
	0.1 —0.25	—	—	—	—	—	trace	—	—	—	—
	0.25—0.5	—	—	—	—	—	trace	—	—	—	—
10	< 0.05	98.0	1.0	—	—	—	—	—	0.5	0.5	—
	0.05—0.1	60.0	35.0	—	—	—	3.0	0.5	—	2.0	—
	0.1 —0.25	—	—	—	—	—	trace	—	—	—	—
	0.25—0.5	—	—	—	—	—	trace	—	—	—	—

Contents of heavy minerals in the examined samples are typical for metamorphic rocks in the surroundings (Chlebowski 1989). Their state of preservation reflects environmetal conditions in the forefield of the glacier. This is the place where the waste material transported by meltwater streams is deposited for the first time. Rock pieces melt out from the ice and are washed off from weathering waste on mountain slopes, lateral moraines and glacier bedrock. In such a dynamic environment most of mineral components disappear even after a very short transport. It refers to all the soft and fissile minerals as amphiboles, pyroxenes, biotite, chlorite and kyanite that are pulverized. In the examined samples only remains of these minerals are present.

Due to impetous transport and intensive physical weathering only the most resistant minerals are preserved. Within fractions the all zircon and tourmaline prevail. They are not fissile but are very hard (approx. 7—7.5 in the Mohs's scale). Typical shapes of these minerals: prisms, rods and their combinations with pyramids are rare. All edges are ground and rounded, and minerals are strongly crushed into pieces. In general tourmalins are more crushed than zircons. Heavy minerals were examined in intramorainal (samples 1—5) and extramorainal sandurs (samples 6—10) but contrary to the geomorphologic and sedimentologic observations, results of mineralogical studies make it impossible distinguish each other (Fig. 1).

High dynamics of glacial retreat, intensive proglacial outflow and wast strong ablation of snow and ice considerably influence sandur deposition. Mineralogical studies confirm that conditions of deposition in intra- and extramorainal sandurs were very similar: their sediments are poorly sorted (see Łanczot 1988) and sets of heavy minerals are the same, as well as amounts and preservation of prevailing zircon and tourmaline.

Conclusions

1. Transparent heavy minerals in sandur deposits from the forefield of the Renard Glacier are concentrated only within the finest fractions (below 0.1 mm).

2. Set of heavy minerals is the same in deposits of intra- and extramorainal sandurs, because they are of the same derivation i.e. from weathered metamorphic rocks of the Hecla Hoek formation.

3. Set of heavy minerals and their state of preservation indicate that deposition processes of the both sandurs are the same. Intensive destruction of fissile minerals by crushing and pulverization proves a very dynamic sedimentary environment. Only the most resistant minerals as zircon and tourmaline are preserved. They are strongly crushed and therefore occur only in the finest fractions (below 0.1 mm).

4. Intra- and extramorainal sandurs can be distinguished only on the ground of geomorphologic studies. In this case heavy minerals is the same in both sandurs. In this case heavy minerals investigations do not allow for distinction of the two kinds of sandurs. Mineralogical criteria, if confirmed in other sandurs, may create a set of diagnostic features useful for determination and correlation of glaciofluvial deposits in Spitsbergen.

5. Set of heavy minerals and state of their preservation suggest that mineral composition of contemporary sandurs from Spitsbergen is quite different than that of the Pleistocene sandur covers from Central Europe. Pleistocene sandur deposits contain many different heavy minerals. Weathered metamorphic, magmatic and sedimentary rocks from Scandinavia as well as local sands and clays from older glacial deposits supplied with these minerals there. Mineral material in Pleistocene sandurs is usually very well rounded. Contrary to the Pleistocene deposits rock pieces in contemporary sandurs are not rounded at all due to very impetous and short transport. Sandurs in the forefield of the Renard Glacier are very scanty because thay have only a single source of weathered material and soft minerals are completely destroyed. In the other parts of Spitsbergen a situation probably will be the same.

6. Geomorphological and sedimentological studies of sandur deposits in Iceland (Klimek 1972, Bogacki 1976) and in Spitsbergen indicate that in similar hydrodynamic conditions, regime and loading of rivers, similar deposits and features are formed. Mineralogical investigations prove that Pleistocene and contemporary sandurs are quite different, especially composition and preservation of heavy minerals in the finest fractions (below 0.1 mm).

7. Analysis of mineral composition of the sandy — silty fractions as well as of metamorphic rocks of the Hecla Hoek formation suggests that scantiness of heavy minerals in sandurs must be compensated by a very diversified composition of loamy deposits in the fiord. Such deposits are to be studied in the vicinity of meltwater streams.

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Streszczenie

Wykonano badania mineralogiczne osadów sandrowych występujących na przedpolu lodowca Renarda w sandrze wewnętrznym i zewnętrznym (fig. 1). Zbadano skład przezroczystych minerałów ciężkich (tabela 1) stwierdzając, że minerały te koncentrują się wyłącznie we frakcjach poniżej 0,1 mm średnicy. Skład i stan zachowania minerałów ciężkich wskazuje na środowisko o bardzo dużej dynamice, co przejawia się bardzo silnym pokruszeniem i zubożeniem składników mineralnych. Dominują głównie dwa składniki: cyrkon i turmalin — najodporniejsze na czynniki wietrzeniowe w środowisku o dominacji wietrzenia mechanicznego. Oba te składniki jak i proporcje ilościowe ich udziału w składzie minerałów ciężkich będą mogły prawdopodobnie stanowić wskaźnik mineralogiczny charakteryzujący współczesne osady sandrowe. Wskaźnik ten różniłby bardzo wyraźnie współczesne osady sandrowe od ich odpowiedników wieku plejstoceńskiego, które charakteryzują się o wiele bogatszym składem minerałów ciężkich jak i stopniem obtoczenia ziarn. Przypuszczenia te jednak są oparte na sondażowych badaniach próbek osadów sandrowych wieku plejstoceńskiego z obszaru NE Polski oraz na pierwszych badaniach mineralogicznych współczesnych osadów sandrowych przedpola lodowca Renarda na Spitsbergenie. Odnośnie kwestii wyróżniania sandrów wewnętrznych i zewnętrznych — badania mineralogiczne nie przyczyniają się do uzasadniania takich wydzieleń; są to wyłącznie wydzielenia według kryteriów geomorfologicznych. Dalsze badania mineralogiczne analogicznych osadów z innych rejonów Spitsbergenu oraz pełniejsze badania utworów plejstoceńskich pozwolą na ewentualne uściślenie powyższych wniosków. Autor zapowiada w najbliższym czasie badania analogicznych osadów sandrowych z przedpola lodowca Scotta na Spitsbergenie.

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