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The largest natural crystal in Poland

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ABSTRACT:

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Gypsum crystals 0.5-3.5 m long occurring in the Middle Miocene (Badenian) gypsum deposits in the northern margin of the Carpathian Foredeep, are the largest mineral crystals in Poland, and represent some of the largest natural crystals in Europe. The crystals spectacular giant intergrowth is similar to the contact 'swallow-tail' $\{\bar{1}01\}$ twins known from other Cenozoic deposits. The intergrowths are arranged in a palisade manner and occur in a distinct stratigraphic a horizon, several meters thick, that is traceable for a distance of approximately 500 km from the Czech Republic in the west to the western Ukraine in the east. In Poland its best exposures are near Busko in the Nida river valley, south of the Holy Cross Mountains, where countless gypsum crystals are 1-1.5 m in length, specimens larger than 2.5 m are rare, and only one crystal approaching 3.5 m of length has been documented. This unique specimen, exposed at Bogucice-Skałki, is the largest known mineral crystal in Poland.

Key words: Large crystals, Gypsum crystal, Miocene, Southern Poland.

INTRODUCTION

The aim of this paper is the discussion and description of the largest mineral crystal in Poland. A critical review and evaluation of the previous reports of the large mineral specimens in Poland is provided and the comparison with other large mineral specimens both in Poland and in other parts of the World is given.

THE LARGEST MINERAL CRYSTALS ON EARTH

Naturally occurring crystals larger than one meter are rare not only because they grew in particular and uncommon environments but also owing to the fact that they are mostly mined out. Such mineral giants were, and are, often weakly documented and because of that, the largest known mineral specimens on Earth are the subject of some controversy.

Since at least the 19th century a story has been told among geologists about a feldspar crystal so large that a quarry was opened solely within its body. Probably QUENSTEDT (1863, p. 226; 1877, p. 272) first mentioned such a feldspar but did not specify its size and source of his information. The crystal was apparently located at Miass in the Ilmen Mountains, southern Urals, a place famous for the green variety of microcline called amazonite, and other rare minerals. However the quarry with such an amazonite specimen was not identified and the crystal size is considered unrealistic (FERSMAN 1937, p. 62; 1940). On the other hand KREUTZ (1924, p. 8), WEYBERG (1925, p. 367; 1929, p. 111) and PENKALA (1956, p. 140; 1965, p. 260) did locate a quarry cut within one feldspar crystal somewhere in Finland. Similar stories were repeated many times by other authors without citation of source data (see LINDGREN 1933, in review by RICKWOOD 1981).

Half a century ago several authors described a quarry cut within a giant microcline feldspar at Devils Hole Beryl Mine, Fremont County, Colorado (HANLEY & *al.* 1950; pers. comm. by L.R. PAGE, 1980, cited by RICKWOOD 1981). The microcline was traced along cleavage planes during mining in open pit and attained a length of nearly 50 m (!). Its size was estimated at

49.4×36.0×13.7 m, volume at 6214 m^3 and a mass at 15,908,890 kg (RICKWOOD 1981). This crystal might have been the largest mineral specimen ever discovered on Earth however evidence that it was really a single crystal remains dubious (RICKWOOD 1981, 1988).

The largest authenticated crystal on Earth was a colossal beryl from Malakialina in the Malagasy Republic, seen by several authors (RICKWOOD 1981, 1988). It was 18 m in length and 3.5 m in diameter, its volume was 143 m^3 and a mass about 380,000 kg (RICKWOOD 1981). This beryl crystal was not documented photographically and it was supposedly mined out before 1967 (JENSEN & FRIGSTAD 1967; P.C. RICKWOOD, personal communication, October, 1998).

The second authenticated largest crystal (in length), also destroyed by mining, but with good photographic evidence, was the 14.33 m long and 0.80 m wide spodumene from the Etta Mine in South Dakota (RICKWOOD 1981, fig. 10). A large number of other mineral giants have existed in the past but were destroyed during mining (FERSMAN 1940, METZ 1964, RICKWOOD 1981).

THE LARGEST MINERAL CRYSTALS IN POLAND

In Poland giant pegmatite minerals were not found. The largest known crystal is of quartz discovered in pegmatites of the Karkonosze granitoid massif, at Żabieniec Hill near Czarne, (housed in Natural History Museum, Humboldt-University, Berlin); it is 1 m long and is 40 cm in diameter (TRAUBE 1888, p. 200; LIS & SYLWESTRZAK 1986; SACHANBIŃSKI 1997, p. 84).

Much larger crystals appear in sedimentary rocks with the largest existing crystal in Poland occurring within Middle Miocene gypsum deposits in the Nida river valley, southern margin of the Holy Cross Mountains (Text-fig. 1A, B). Giant gypsum intergrowths, several meters long, have long been known from there (ZEJSZNER 1861a, KONTKIEWICZ 1882, KREUTZ 1925) and have attracted the attention of many natural historians. However, in spite of a very extensive literature, the reports about maximum sizes of these crystals are surprisingly not in accord. Some wrote that the crystals are from 4 to even 7.5 m long, whereas others claimed that the same crystals are only 2-3.5 m long.

Such extremely contradictory opinions have never been discussed and critically evaluated and a true size for the largest mineral in Poland has not been established. Although the author indicated one crystal as the largest of all those existing at present (BĄBEL 1996, fig. 2), it was not described in detail and not compared with other giant specimens recorded in the past.

MAIN FEATURES OF GIANT GYPSUM INTERGROWTHS

Giant gypsum intergrowths occur within evaporite deposits of Middle Miocene (Badenian) age cropping out in the Nida river valley near the town of Busko (Text-fig. 1A, B). The crystals appear as a row of subvertically elongated prisms within one layer at the base of evaporite sequence. This layer is composed entirely of decimeter and meter size crystals and looks like a huge palisade. In the Nida area there are countless numbers of such giant crystals which show comparable sizes in many outcrops located within an area ca 15×30 km. Because of that, previous investigators generally described the crystal sizes without measuring any single specimen or giving a particular locality.

The gypsum intergrowths, occurr in nearly the whole northern Carpathian Foredeep. The giant-crystal layer up to 8 m thick (KUBICA 1985), has been traced in outcrops and drill cores along a more or less continuous arcuate belt, up to 50 km wide, a distance of about 500 km. The westernmost outcrops are at Kobeřice in the Czech Republic, the easternmost – at Bilohirka and Odaiv in Ukraine (Text-fig. 1A, PERYT & *al.* 1998). The exposures in the Nida area are only a small part of this peculiar layer, commonly 3.5 m thick.

The intergrowths originated in an uncommon environment. They are primary evaporite deposits formed in a vast shallow saline pan where they grew at its base forming a true crystal forest which continued over a distance of many hundred kilometers. The brine column was density stratified and only the bottom brines were saturated with calcium sulphate. Due to low supersaturation, and/or organic compounds inhibiting the crystallization, gypsum nucleation was sparse and the crystal growth was mostly syntaxial, similar to growth in mineral druses (see BĄBEL 1999). The protracted period of upward growth led to formation of extraordinarily large individual crystals.

The other curiosity is the peculiar crystallographic nature of the intergrowths. Although similar to the contact {101} gypsum twins, the intergrowths differ from twins in lacking any crystallographic symmetry between component crystals. Many features and data suggest that they are representative of a very peculiar type of organically-controlled mineral intergrowths so far recognized only in the Carpathian Foredeep (BĄBEL 1991, 2000). The other uncommon feature well represented in the Nida area is the primarily skeletal structure of the giant crystals.

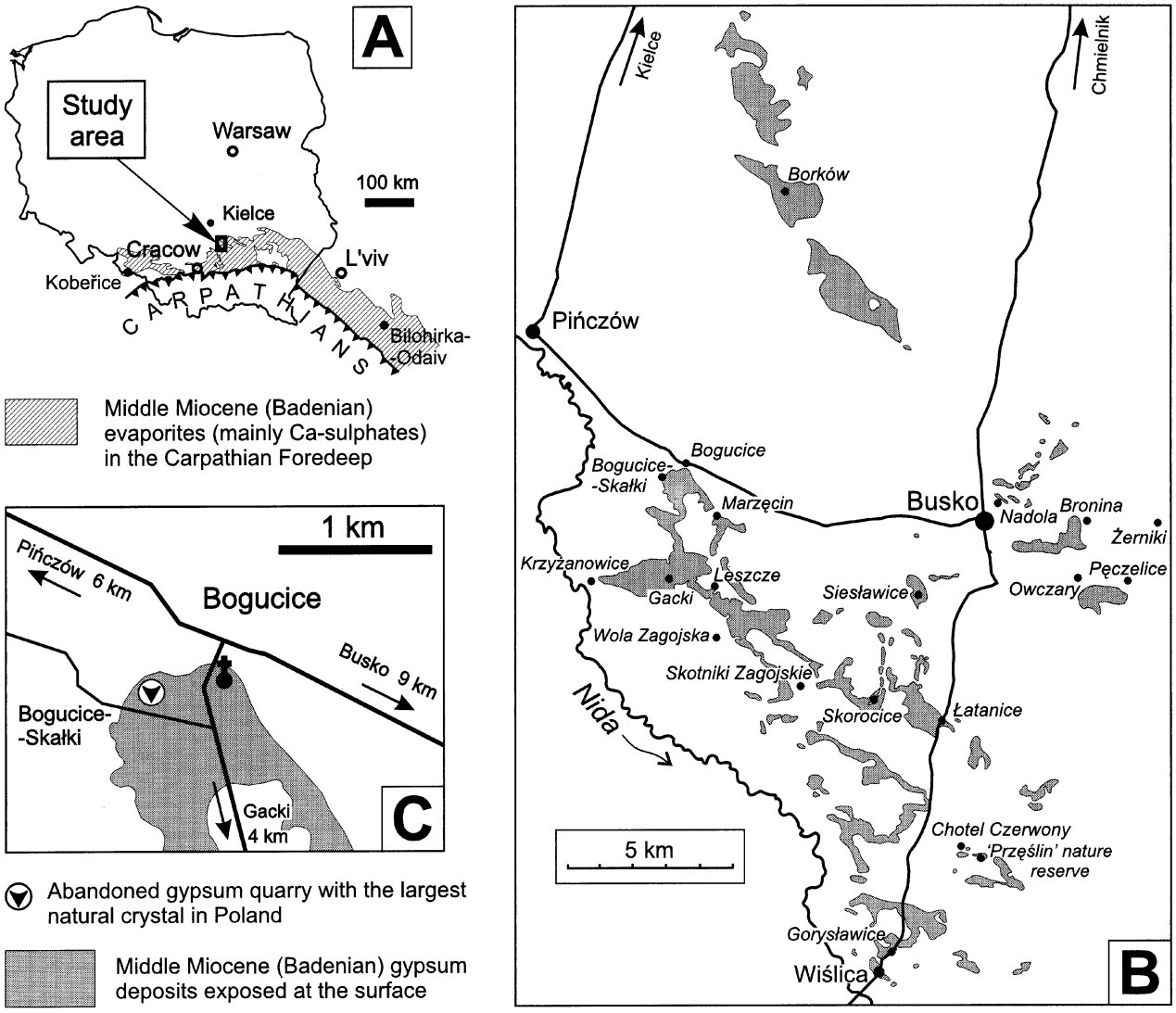

Fig. 1. A – Location of the study area of the Middle Miocene (Badenian) evaporites; B – Exposures of the Middle Miocene (Badenian) gypsum in the Nida river valley (after various sources and author's own data) and location of outcrops mentioned in the text; C – Location of the outcrop with the largest gypsum crystal

SIZES OF GIANT GYPSUM INTERGROWTHS IN LITERATURE

Records of giant crystal intergrowths in Poland have been compiled in Appendix; but only the most important are discussed here. Localities with the largest specimens are shown in Text-fig. 1B.

The first information concerning the size of the giant gypsum intergrowths was given in 1836 by G. PUSCH who described them as up to about 1.2 m long.

A quarter of century later L. ZEJSZNER visited nearly all of the known gypsum exposures in the Nida area during field work which started in 1857. He described gypsum outcrops in detail and noted exceptionally long, (about 3 m), gypsum crystals occurring at Gorysławice near Wiślica (ZEJSZNER 1861a, b; 1862; 1863) and mentioned 2.60 m long crystals near Owczary and Pęczelice (footnotes 3-6 after Appendix).

Twenty years later S. KONTKIEWICZ did the pioneering geological mapping of the Nida area and described 3 m long crystals from quarries at Wiślica and suggested that similar crystals occurred also at Krzyżanowice (KONTKIEWICZ 1882, 1884). Later KONTKIEWICZ (1907, 1915, 1919) wrote that the gypsum crystals are up to 4 m long however he did not indicate any particular locality but one can guess that it could be a hill near Skotniki Zagojskie from where he had earlier described giant-crystal layer attaining 4 m in thickness (KONTKIEWICZ 1882, 1884).

Forty years later the giant intergrowths were studied by S. KREUTZ who stated that crystals were 1-2.5 m long (KREUTZ 1925, p. 64), or over 2 m long (KREUTZ 1929, 1930, 1932), and did not indicate any specific locality.

Many subsequent authors apparently based sizes estimates on ZEJSZNER's, KONTKIEWICZ's and KREUTZ's data (Appendix).

After World War II Polish authors described the giant intergrowths giving very different crystal sizes from 2 up to even 7.5 m (Appendix) but smaller sizes were recorded especially by those who made detailed field studies in the Nida area.

In his early publications KWIATKOWSKI (1966, p. 26; 1970, p. 7, 52) estimated the maximum crystal sizes to be 3 m but later he extended these to 3.5 m (KWIATKOWSKI 1972, 1974) without indicating any locality. His view was widely accepted and it has been confirmed by the present author who noticed a crystal approaching 3.5 m in length (footnote 34 after Appendix).

EVALUATION OF LITERATURE DATA ON SIZES OF GIANT INTERGROWTHS

Many previous authors collected their information in operating quarries and at outcrops which no longer exist or are mined out, so it is difficult to authenticate their data. Unfortunately, the evidence from recent outcrops does not support many of the earlier estimates of the size of gypsum crystals.

The giant intergrowths are visible on many published photos, however as a rule the sizes of particular specimens are not exactly specified. Previously, only single specimens were accurately measured and documented and only the crystal from Bogucice-Skałki (about 3.5 m long; BĄBEL 1991, p. 116; pl. 1, phot. 1; 1996, fig. 2) and the intergrowth from Chotel Czerwony (2.7 m long; BĄBEL 1981, pl. 1a; GĄSIEWICZ 1994, pl. 8, figs 27, 28; KASPRZYK 1993b, fig. 9) were both measured and photographically illustrated and are still available in the field. The other comparably large specimens are poorly documented.

A. BOLEWSKI with various co-authors often indicated Gacki and Gorysławice as localities of 5 and 4-5 m long specimens but an occurrence of such gigantic crystals is doubtful there because the thickness of the entire giant-crystal layer is only 3.5 m at Gacki and 3-4 m at Gorysławice. 4-5 m long crystals were claimed to occur also at Krzyżanowice and Bogucice and 3 m long specimens at Chotel Czerwony, Łatanice, Skorocice, Gacki, and Marzęcin (Appendix, Text-fig. 1B). Such crystals were not found by the author at these localities but, recently, KASPRZYK & *al.* (1999) have noted 4 m long intergrowths at Borków but did not provide any further documentation.

ZEJSZNER (1861b, 1863) first discovered ca 3 m long crystals at Gorysławice, and although he did not supply illustration, he described them precise to *a foot*, i.e. 32.5 cm (see footnotes 3-6 after Appendix). He also noted crystals smaller than about 2 m at Gorysławice which suggests that he really measured particular specimens at this locality. ZEJSZNER's data coincide with observations by KONTKIEWICZ (1882) who also described 3 m long crystals nearly at the same place, Wiślica. Today only remnants of these spectacular outcrops can be seen at Gorysławice and the exposed crystals are up to 2 m long.

Although KONTKIEWICZ (1882) described and pictured 3 m long crystals at Wiślica, and suggested an occurrence of such crystals at Krzyżanowice, his data seem less reliable. He always used round numbers of meters in descriptions of the giant intergrowth sizes so one can only infer that he was accurate within 1 m. Moreover his drawings do not reflect the true structure of the giant-crystal layer (see comment in the next section). Such inaccuracies throw doubt on his other descriptions of crystals at Skotniki Zagojskie – [the supposed locality of 4 m long intergrowths (footnote 9 after Appendix)] and the present author did not find 3 or 4 m long crystals at any sites indicated by KONTKIEWICZ.

None of the other authors who suggested crystal sizes larger than 3.5 m supplied reliable illustrations and documentation. None indicated that the specimens were measured, none gave a precise location, and none indicated a source for the information if it was not stated to be their own.

The statement that the crystals are up to 4 m long is very common in the literature, its source being KONTKIEWICZ (1882 and later publications), but regrettably his documentation is not fully convincing.

CRYSTAL SIZE ORIENTATIONS

KONTKIEWICZ (1882, 1907) repeated many times that crystal prisms are parallel and extend from the base to the top of the giant-crystal layer, standing normal to the substrate (footnotes 7-9, 13 after Appendix). This description

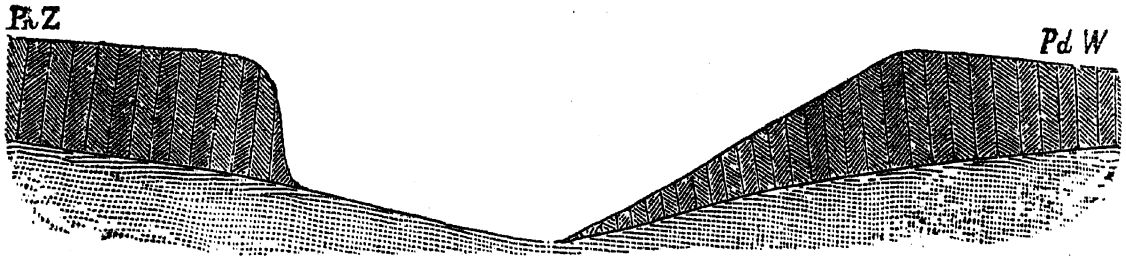

Fig. 2. Original picture by KONTKIEWICZ (1882, fig. 4) illustrating supposed locality of 4 m long gypsum crystals nearby Skotniki Zagojskie

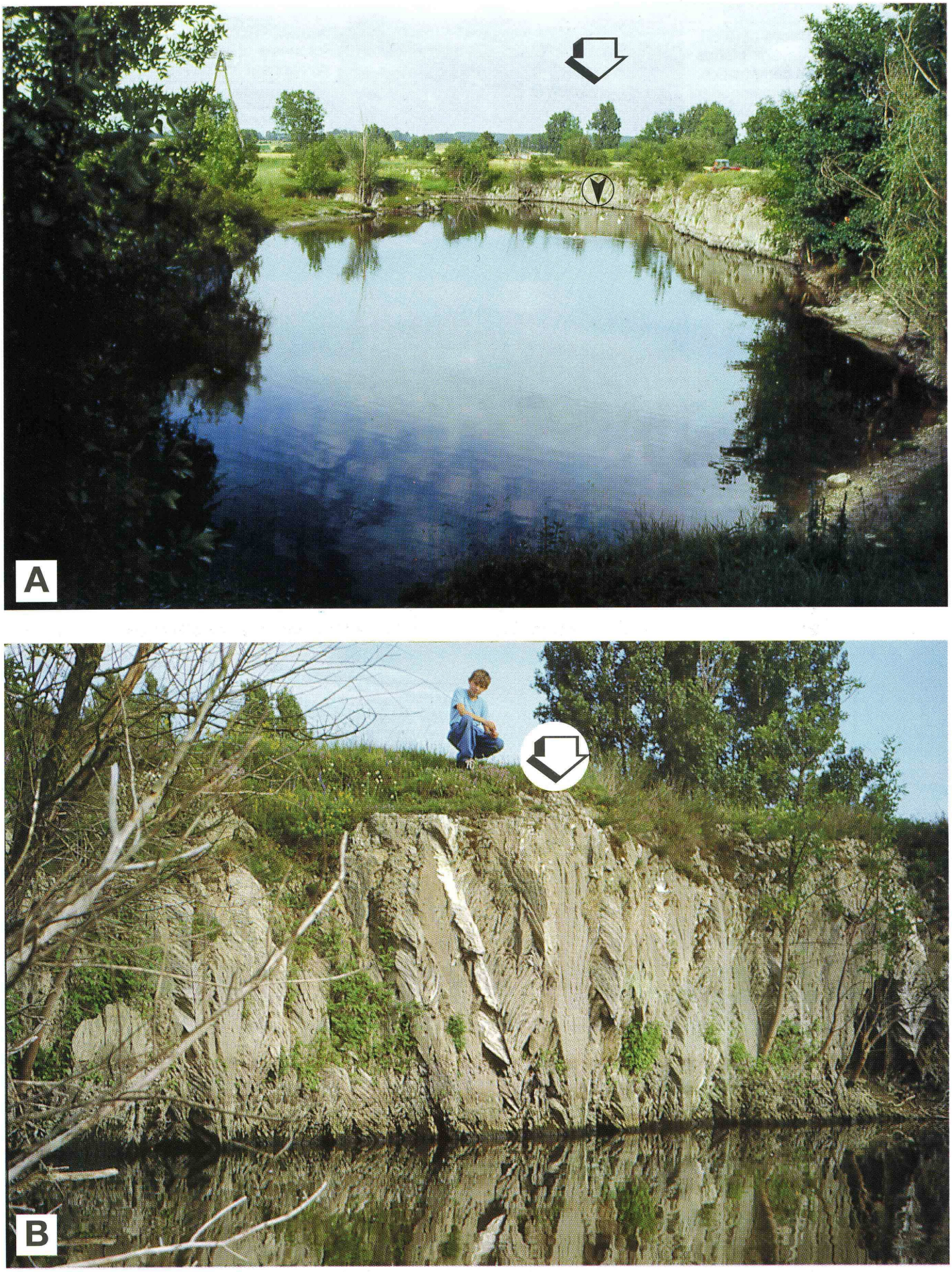

Fig. 3. A – Abandoned gypsum quarry at Bogucice-Skałki, view facing north. The largest crystal is arrowed and circled. B – The largest gypsum crystal (*arrowed*) exposed in the quarry wall at Bogucice-Skałki

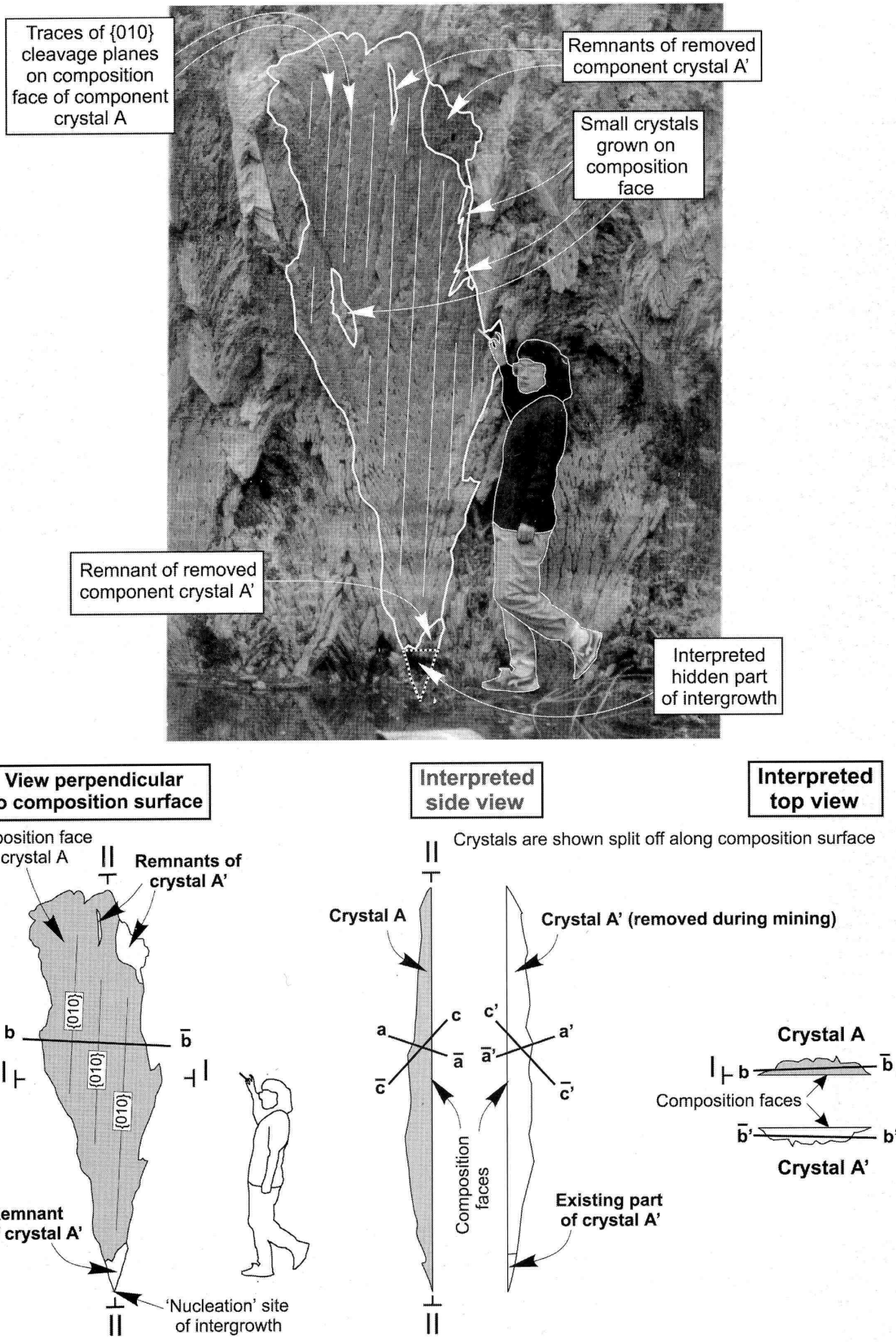

Fig. 4. Reconstruction of the largest gypsum intergrowth from Bogucice-Skałki. Composition face is outlined in the photo and redrawn in the picture below with correction for optical shortening. Full sizes of intergrowth are arbitrary reconstructed basing on typical habit of intergrowths. Crystallographic axes (**a**, **b**, **c**) and {**010**} cleavage of gypsum are marked (*see* BĄBEL 1991 *for further details*

Fig. 5. The largest mineral crystal in Poland exposed within a palisade of giant gypsum intergrowths at Bogucice-Skałki. Photo taken by A. ŚWIERCZEWSKA in 1992

is oversimplified yet is supported by KONTKIEWICZ's pictures which show the ideal palisade of parallel, regular, prisms as high as the thickness of the bed (Text-fig. 2). Nowhere do the crystals form ideally parallel prisms oriented normally to the substrate and many published photos reveal that the long axes of the crystals are in fact subparallel one to another and subvertical in relation to the growth substrate or base of the layer. The deviation from a vertical position varies from place to place from several degrees up to a few tens of degrees and in some places the crystals are even subhorizontal (BĄBEL 1987). The best description is that of KREUTZ (1925, p. 63) *"the layer of twinned crystals (...) uprising nearly perpendicularly to the substrate and commonly nearly parallel to each other"* (underlining added by the author).

The giant crystals are commonly stacked or grown one upon another within a single layer. The syntaxial upward growth of gypsum crystals on the Badenian saline pan floor being, from time to time, associated with seeding or nucleation of new crystals on their upper faces. In reality the longest and widest crystals occur in the middle part of the bed. Generally, both at the base and the top of the layer, the crystals are smaller (several cm) and arranged subhorizontally or even randomly. Only some sporadic single intergrowths extend from the base to the top of the layer and those are more rare in the thicker layers.

Basing crystal sizes on the thickness of the giant-crystal layer, especially when it is known from drill cores, leads to a great overestimation of these sizes. KREUTZ (1925) was aware of it, and probably because of that he was skeptical of both KONTKIEWICZ's and ZEJSZNER's data (footnotes 15-16, 20 after Appendix).

THE LARGEST GYPSUM CRYSTAL IN RECENT OUTCROPS

Recent field evidence from the Nida area contradicts the opinions that the crystals are longer than 3.5 m and 4-7.5 m long crystals (see Appendix) have never been observed by the author in this area. Recent exposures supply countless examples of 1-1.5 m crystals, those larger than 2 m are relatively rare, and only a few specimens surpassing 2.5 m in length are known. Only one crystal, described below, is longer than 3 m.

The largest gypsum crystal is exposed in an abandoned quarry at Bogucice-Skałki (Text-fig. 1C). The outcrop, which is presently protected by law, was previously illustrated by BĄBEL (1991, pl. 1, phot. 1; 1996, fig. 2) and KASPRZYK (1993a, pl. 1, fig. 1).

The quarry is filled with water so the huge palisade of upright intergrowths is fully visible only during the dry summer seasons (Text-fig. 3A). The largest crystal is in the eastern 3-4 m high wall of the quarry cut in the giant-crystal layer (Text-fig. 3B). The giant crystal is exposed in the northern part of that wall; it shows a characteristic flat composition face[1] (footnote 1 after Appendix) along which it formed an oriented intergrowth with the adjacent crystal of the same record size (Text-figs 4-5). This missing component crystal was split off along a composition surface and it was nearly entirely removed during mining.

The crystal seen in the wall of the quarry resembles a giant fan. Its relief is created by 0-9 cm high subvertical and radially oriented steps and is a typical growth feature of the intergrowths which reflects a serial splitting of the apical area of an intergrowth during the upward vertical growth (BĄBEL 1987, fig. 4). It is this fan-like relief and parallel traces of {010} cleavage planes on the composition face (Text-fig. 4) which prove that the specimen is really a single crystal.

The zig-zag shape of the apex (Text-fig. 4) causes that a long axis of the crystal can occupy different positions. Hence, depending on the place of measurement, the crystal length ranges from 3.00 to 3.15 m. In the middle part the crystal reaches 1 m in width. The lowermost part of the crystals – the 'nucleation' site of the intergrowth from where the component crystals started their common upward growth – is hidden within the gypsum bed itself. However the fan-like or triangular shape of the composition face can be traced down to this 'nucleation' site (by analogy to the other well exposed composition faces from the same locality, see BĄBEL 1991, pl. 7, phot. 15, and from the other localities; see BĄBEL 1987, fig. 4b, pl. 2, fig. 1, pl. 8, fig. 1; 1991, pl. 3, fig. 8; KASPRZYK 1993a, pl. 2, fig. 1, 1999, pl. I, fig. 1). This allows a rough estimate to be made of the length of the hidden part. Taking into account a considerable width of the crystal in its lowermost visible part, and a visible span of fan-like relief, an unexposed part of the crystal was graphically reconstructed (Text-fig. 4) and estimated at minimum 25 cm of length (although it could be even 40 cm long). Thus the crystal length is at least 3.40 m, or may be even 3.55 m. Because the apex of the crystal is partly destroyed, the present minimum 3.40 m size was larger in the past. Thus it is reasonable to estimate with an accuracy to ±10 cm that the crystal is (or was) approximately 3.50 m long.

The surface area of composition face of the giant crystal, together with its reconstructed lower part (Text-fig. 4), equals about 2.052 m^2. A third dimension of the crystal in direction perpendicular to the wall of the quarry and to the composition face, by analogy to the typical habit of intergrowths always flatted along composition surface, can be estimated as not exceeding 0.5 m. Assuming that this dimension is 20 cm on average, the crystal volume equals ca 0.4104 m^3 and its mass is ca 952 kg.

COMPARISON WITH THE OTHER LARGE GYPSUM CRYSTALS

Giant gypsum crystals are not a rarity being particularly common in Cenozoic evaporite deposits. The largest specimens were described from the Messinian (Upper Miocene) gypsum deposits of the Mediterranean where all are twinned on the {100}.

The largest known evaporite gypsum twins include: the 6 m long specimen from Buraitotto, SE Favara in Sicily (RICHTER-BERNBURG 1973), and 4.5 m long twins cropping out E of Eledhiou in Cyprus (ROBERTSON & *al.* 1995, p. 239). In Cyprus twins 5 m long (ROUCHY 1982, p. 153) or even 7 m long (SCHREIBER 1978, 1988) have also been recorded. Prof. B.C. SCHREIBER (personal communication, July, 2001) kindly supplied the following description of the unique specimens attaining 7 m sizes: "The outcrops of very tall (4-7 m), narrow, regular, Messinian gypsum crystals in one area of Cyprus were noted not more than 10 km from Paphos (N-NE), at several sites along a country road. The crystals are uniformly vertical and narrow (10-20 cm wide) and twinned on a vertical twin plane that runs down the centre of each [twinned] crystal (appearing in the form of the ferro-dilancia). The exposure faces are regular with the {010} cleavage faces of all the long narrow crystals more or less aligned to the front face of the outcrops. When examined from the top of the bed all crystals are also radially twinned, so possible cleavage faces were available every few degrees (at about 20-30 degree intervals), and thus resulted in the very regular arrangement of the exposure face".

Similarly to the Polish giant intergrowths, the Upper Miocene {100} twins are arranged in a palisade manner, however, they are more parallel and narrower. In Cyprus the 7 m long crystals may be 10 cm (ROBERTSON & *al.* 1995) to 20 cm in width (ROUCHY 1982, p. 153; SCHREIBER 1988). Thus these crystals are approx. 0.28 m^3 in volume, and a mass of individual specimens can weigh ca 649.6 kg, assuming a 0.2×0.2 m transverse section. These gypsum twins and intergrowths are undoubtedly among the largest existing natural crystals; they are the longest gypsum crystals in Europe but the Polish specimens apparently have a greater volume and mass.

The largest known gypsum crystals were found in cave deposits. The largest specimens, presumably {100} twins, were recently discovered in the Cave of the Crystals (Cueva de los Cristales) at Naica, SE of Chihuahua, in Mexico. A least 20 crystals in this cave are between 5 and 7 m long and some are almost 1.5 m in diameter (LAZCANO SAHAGUN & *al.* 2001; C. LAZCANO SAHAGUN, personal communication, February, 2002). Some visitors claim that the specimens are up to 15 m long (Internet sources). The large crystals from other caves are significantly smaller. In the famous Cave of Swords (La Cueva del Espadas), at the same locality Naica, the {100} twins are only 2.5 m long and 0.15-0.20 m wide (PANCZNER 1987, p. 18, 221). In Santo Domingo cave near Aquilles Serdán, E of Chihuahua (PANCZNER 1987, p. 14-15; 220, fig. 15, 16), a 3.9-4 m long and approx. 0.12 m wide {100} twin was found, together with 50-60 other 2-3.7 m long specimens. From the same area PANCZNER (1987, p. 220) mentioned 12 m long crystals, however without any details. A gypsum crystal 3 m long and 0.6-0.9 m in diameter was found in a cavern at El Teniente (Braden) copper mine in Chile (LINDGREN & BASTIN 1922; LINDGREN 1933, p. 685). Regrettably most of these cave crystals have been destroyed.

SUMMARY AND FINAL REMARKS

The largest authenticated crystal in Poland is of gypsum and approx. 3.5 m long (from Bogucice-Skałki); 3 m large crystals once occurred in outcrops between Gorysławice and Wiślica. Only this first crystal still exists and it is the largest documented and preserved mineral specimen in Poland.

This 3.5 m gypsum crystal in Poland has not been listed in encyclopedias and the author hopes that its discovery will prompt future quests for even larger mineral giants not only in Poland but in the other countries as well. It is quite probable that somewhere in the Nida river valley there are crystals longer than 3.5 m. Poorly documented 4 m giant intergrowths suggest they may have been present when earlier geologists working in the Nida area had greater chances to find such specimens because of the many small gypsum quarries that formerly operated there. Today only two large quarries are working and supply a limited new material for observation; the abandoned quarries are devastated and offer poor exposures. The thickness of the giant-crystal layer in the Nida area locally reaches 6 m, so it is possible that some crystals could attain the same length, or even larger if they grew obliquely to the depositional surface.

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Appendix

Sizes of giant gypsum intergrowths in southern Poland

Authors	Maximum size of crystals	Localities of the largest crystals
Pusch (1836, p. 362), [Anon.] (1838, p. 450-451)[2]	1.2 m*	Not indicated
Zejszner (1861a)[3]	2.95 m*	Gorysławice
Zejszner (1861b, 1863)[4]	3.25 m*	Gorysławice
Zejszner (1861b, p. 715; 1862, p. 32)[5]	2.60 m*	Environs of Owczary and Pęczelice
Zejszner (1863, p. 725)[6]	2.95 m or 3.25 m*	Nadola near Busko
Kontkiewicz (1882, 1884)[7]	3 m	Wiślica
Kontkiewicz (1882, 1884)[8]	3 m#	Krzyżanowice
Kontkiewicz (1882, 1884)[9]	4 m#	Hills nearby Skotniki Zagojskie
Kosiński (1884, p. 75)[10]	6.9 m to 8.5 m*	Not indicated
Rugewitsch (1884, p. 201)[11]	3.25 m*	Not indicated
Rugewitsch (1884, p. 202)[12]	2.60 m*	Between Busko, Bronina, Żerniki and Pęczelice
Kontkiewicz (1907, 1915, 1919)[13]	4 m	Not indicated
Siemiradzki (1909)[14]	3 m	Wiślica, Krzyżanowice
Kreutz (1924, p. 8)[15]	3 m	Not indicated
Kreutz (1925)[16]	2.5 m	Possible localities: Chotel Czerwony (the most often mentioned and illustrated), Bogucice, Krzyżanowice, Skorocice, Łatanice, Gorysławice, Wiślica, Siesławice, Pęczelice
Morozewicz (1925, 1931)[17]	3 m	Gorysławice, Wiślica (Morozewicz 1931)
Weyberg (1925, p. 367)[18]	3 m	Not indicated
Weyberg (1929, p. 190, 486)[19]	3 m and 4 m	Not indicated
Żelechowski (1925, p. 136)	3 m	Gorysławice, Wiślica
Kreutz (1929; 1930, p. 5, Fot. 5; 1932)[20]	Over 2 m	Locality not specified; Chotel Czerwony is most often mentioned
Szafer (1932)[21]	3 m	"Przęślin" nature reserve at Chotel Czerwony
Łaszkiewicz (1936, p. 160)	3 m	Skorocice
Hessel-Zaleska (1950, p. 9, Ryc. 9)[22]	3 m	Skorocice
Akerman & Nielubowicz (1951)[23]	5.0 m#	Not indicated
Jurkiewicz (1951)[24]	5 m#	Not indicated
Lazarek (1952, 1957)	3 m	Not indicated
Trembecki (1952)	4 m	Not indicated
Gaweł (1955)[25]	3 m and 4 m	Not indicated
Morawiecki (1955)	Over 3 m	Not indicated
Bolewski & Budkiewicz (1956)	4-5 m	Not indicated
Maślankiewicz (1957, p. 317; 1966a, p. 180, 183; 1967, p. 303)	Over 2 m	Not indicated
Medwecka-Kornaś (1959)	3 m	Nature reserve at Chotel Czerwony
Skalmowski (1959)[26]	6 m#	Not indicated
Nielubowicz (1961)[27]	6 m#	Not indicated
Wala (1961)[28]	3-4 m#	Not indicated
Bolewski & Turnau-Morawska (1963), Bolewski (1969, 1970)[29]	4-5 m	Gacki, Gorysławice
Kubica (1965)	4 m	Not indicated
Kwiatkowski (1966, p. 26; 1970, p. 7, 52)	3 m	Environs of Wiślica (Kwiatkowski 1970, p. 7)
Maślankiewicz (1966b, 1970, 1973)[30]	3 m	Locality "Krzyżanowice" (properly: Gacki) is given in Maślankiewicz (1970, phot. on p. 551)

FIJAŁKOWSKA & FIJAŁKOWSKI (1968)	3 m	Environs of Wiślica
KUBICA (1968a, b)	3 m	Gacki quarry
PAWŁOWSKI (1968, 1970, p. 622, 1980, p. 589)	4 m	Not indicated
JAKUBOWSKI (1971)	3 m	Nature reserve at Chotel Czerwony
KOZŁOWSKI & *al.* (1971), KOZŁOWSKI (1975, 1986), KOZŁOWSKI & LESZCZYSZYN (1986)[31]	3.5 m	Not indicated
KWIATKOWSKI (1972, 1974)	3.5 m	Not indicated
ŁYCZEWSKA (1972, 1975)	3 m	Not indicated
BOLEWSKI & PARACHONIAK (1973)	5 m	Not indicated
BOLEWSKI & PARACHONIAK (1974, 1978, 1982, 1988)	5 m	Possible localities: Gacki, Krzyżanowice, Bogucice, Gorysławice
GAWEŁ & WÓJCIK (1974)	3 m	"Przęślin" nature reserve at Chotel Czerwony
WYTRWALSKI (1976)	3.5 m	Not indicated
CZUBIŃSKI & *al.* (1977, p. 88)	3 m	"Przęślin" nature reserve at Chotel Czerwony
SCHREIBER (1978)	4 m	Not indicated
STUPNICKA & RYŁKO (1978)	4 m	Not indicated
PAWŁOWSKI & *al.* (1979, Fig. 4)[32]	Over 3 m	Not indicated (probably Łatanice)
POLKUNOV & *al.* (1979, p. 136)	4 m	Not indicated
BĄBEL (1981, Pl. Ia)[33]	3 m	Chotel Czerwony, west of church
HAŁAS & KROUSE (1981)	4 m	Not indicated
SIEMIŃSKA (1982)	6.5 m	Not indicated
RUTKOWSKI (1983)	2-7.5 m	Not indicated
BĄBEL (1984, 1987, 1999, 2000)[34]	3.5 m	Not indicated
PARAFINIUK (1985)	3.5 m	Not indicated
RADWAŃSKI (1985, 1991)	3 m	Not indicated
NOWAK (1986)	3.5 m	Not indicated
RUTKOWSKI (1986)[35]	3.5-5 m	Not indicated
PAWŁOWSKI & *al.* (1987, 1990)	7 m	Not indicated
WYRWICKA (1987, 1990)	3.5 m	Not indicated
KASPRZYK & OSMÓLSKI (1989)	3.5 m	Not indicated
BĄBEL (1991, p. 116, Phot. 1; 1996, Fig. 2)	3.5 m	Bogucice-Skałki
BOLEWSKI & *al.* (1991a, b)	4 m	Gorysławice (BOLEWSKI & *al.* 1991a, p. 427)
ALEXANDROWICZ & *al.* (1992)	3 m	"Przęślin" nature reserve at Chotel Czerwony
KASPRZYK (1993a, b, c; 1999)	3.5 m	Not indicated
KASPRZYK (1993 b, Fig. 9)	2.7 m	Chotel Czerwony, west of church
GĄSIEWICZ (1994, 2000)	3.5 m	Not indicated
GĄSIEWICZ (1994, Fig. 27)	2 m	Chotel Czerwony, west of church
PERYT & *al.* (1994)	4 m	Not indicated
SYLWESTRZAK (1997)	3 m	Environs of Wiślica
TURCHINOV (1997)	4 m	Not indicated
GUBAŁA & *al.* (1998)	3.5 m#	Not indicated
CUKIERSKA (1999)[36]	3.5 m	Not indicated, up to 2.5 m at "Przęślin" nature reserve at Chotel Czerwony
KASPRZYK & *al.* (1999)	3.5 m and 4 m	4 m at Borków quarry
URBAN & WRÓBLEWSKI (1999)	3.5 m	Not indicated
BARCICKI & NOWAK (2000)	2.5 m	Not indicated
WRÓBLEWSKI (2000, p. 57)	3 m and 3.5 m	Marzęcin (3 m) and Bogucice-Skałki (3.5 m)

* transformed from old units of measure

size suggested by description of giant-crystal layer (crystal length coincides with thickness of the layer)

[1] crystallographically oriented surfaces of component crystals adjoining each other and creating together a composition surface of the intergrowth were named **composition faces**; BĄBEL 1991, p. 108.

[2] In original German text "3-4 Fuss" (PUSCH 1836, p. 362). According to ANON. (1838, p. 450) "so grosse Krystall-Partien sind sonst in dem Gypse nicht bekannt".

[3-6] L. ZEJSZNER used an old measure *in feet*, different than the recent Imperial unit [*italics are used here and in the whole text to mark this difference*], which at his time was not uniform in Europe. The author assumed that ZEJSZNER employed French *pied a roi* measure, equals 0.32484 m, the most often used on territory of Poland than (PANKIEWICZ 1867). ZEJSZNER in his book, published in 1861, noted *6-9 feet* long crystals at Gorysławice near Wiślica (in Polish text: "6-9 stóp"; ZEJSZNER 1861a, p. 490-491). However in his paper printed in the same year he wrote that the crystals at this locality were slightly larger: *6 and 10 feet* long ("6 i 10 stóp"; ZEJSZNER 1861b, p. 236; 1862, p. 7), and commonly "*6 to 10 feet*" long (6 do 10 stóp; ZEJSZNER 1861b, p. 719; 1862, p. 36). The discrepancy between ZEJSZNER's measurements of *9 and 10 feet* at Gorysławice requires a comment. ZEJSZNER apparently measured the crystals exact to *a foot* because he did not used a fractional division. Hence one can guess that the specimens might be in fact between *9 and 10 feet* (i.e. 2.92 m and 3.25 m). It seems that ZEJSZNER hesitated and at the beginning choose the lower size equal 9 (ZEJSZNER 1861a) and than extended it to the more round and pronounced 10 (ZEJSZNER 1861b, 1862, 1863). If that is true than the crystal sizes at Gorysławice equalled about 3 m rather than 3.25 m. The round value of 3 m was accepted by later authors (e.g. KREUTZ 1925, 1932). An alternative explanation that ZEJSZNER first found *9 feet* long crystals and later other *10 feet* long specimens is less probable because in his texts he mentioned a pair of measurements: 6-9, and 6-10, which means that he replaced 9 with 10 in the later publications. According to ZEJSZNER (1861b, p. 236; 1862, p. 7) 3 m size of crystals from Gorysławice was exceptional among studied intergrowths. The giant specimens were visible *"in many places"* (ZEJSZNER 1861b, p. 719; 1862, p. 36) [*citations of Polish texts in this paper are translated into English by the author*] in a gypsum wall rising above Gorysławice village, at a side of the wall turned towards three small "Kardynał" hills protruding from the Nida flood plain west of Wiślica. In the paper published in 1863 ZEJSZNER listed, together with Gorysławice, the second locality with *6 to 10 feet* long crystals: Nadola near Busko ("6 do 10 stóp"; ZEJSZNER 1863, p. 725), however, from his description it is unclear whether the crystals were up to 10 or only up to 6 *feet* long there. The maximum crystal size of *10 feet* was once more confirmed in the other fragment of the same text (ZEJSZNER 1863, p. 733).

[7-9, 13] S. KONTKIEWICZ described several gypsum sections including four with the giant crystals: Wiślica, Krzyżanowice, Wola Zagojska, and Skotniki Zagojskie. At Wiślica, in quarries at a northern side of the town, he noted 3 m long intergrowths (KONTKIEWICZ 1882, p. 187-188, Fig. 5; 1884, p. 62). The specified location was just across from the southern part of Gorysławice, very close to the area where earlier ZEJSZNER recorded 3 m long crystals (Text-fig. 1B). Strangely enough KONTKIEWICZ did not describe the spectacular gypsum wall admired by Zejszner, within a distance less than 0.5 km N of Wiślica. KONTKIEWICZ did not mention and discuss any of ZEJSZNER's data on the Gorysławice locality, even though this important section was one of the few drawn by ZEJSZNER (1861b, Fig. 6), and the only one where he had discovered 3 m long crystals 21 years earlier. KONTKIEWICZ nowhere mentioned ZEJSZNER's measurements (although he commented on ZEJSZNER's papers very critically; see KONTKIEWICZ 1882, p. 179) and himself described other places with the giant crystals claiming that some specimens were even 4 m long (KONTKIEWICZ 1907). At Krzyżanowice he described a *"gypsum layer, about 3 m thick, composed of giant vertically standing crystals, which are as long as thickness of the whole layer"* (KONTKIEWICZ 1882, p. 186, Fig. 2; 1884, p. 60). At Wola Zagojska he noted 2 m thick layer showing the same ideal palisade arrangement of crystals (KONTKIEWICZ 1882, p. 157; 1884, p. 61). He recorded that the same layer with crystals *standing perpendicularly to the substrate* is 4 m thick on western slope of gypsum hills nearby Skotniki Zagojskie (KONTKIEWICZ 1881; 1882, p. 187, Fig. 4; 1884, p. 61-62). Although he did not specify the crystal sizes at this locality his description and illustrations suggest that the crystals were 4 m long there (Text-fig. 2). The hachure used by KONTKIEWICZ (1882, Figs 2, 4, 5) on all the pictures of outcrops at Wiślica, Krzyżanowice, and Skotniki Zagojskie showed ideally parallel prisms extending from the base to the top of the giant-crystal layer. Later in three editions of his textbook KONTKIEWICZ (1907, 1915, 1919) expressed the univocal opinion that the crystals, *"standing parallel to each other and perpendicular to the base of the layer"*, are up to 4 m long. Regrettably he did not indicate any locality.

[10] J. TREJDOSIEWICZ, who prepared and published field manuscripts by W. KOSIŃSKI, wrote that *"the crystals are sometimes 4 sążnie long; i.e. they extend through the whole thickness of the bed"* (KOSIŃSKI 1884, p. 75). The old measure 1 *sążeń* (*sążnie* in plural) equaled 1.728 to 2.134 m which means that the crystal length was estimated between 6.9 and 8.5 m (!).

[11-12] RUGEWITSCH (1884) knew the papers of ZEJSZNER (1861b) and KONTKIEWICZ (1884) but confirmed only selected data by the former author.

[13] see footnotes 7-9

[14] In his monographic book SIEMIRADZKI (1909, Figs. 4, 6, 7, pp. 232-233) repeated in detail the documentation of KONTKIEWICZ (1882).

[15-16, 20] In his early publication KREUTZ (1924, p. 8) believed that the crystals are 3 m in size, an estimate based on ZEJSZNER's and KONTKIEWICZ's data (see KREUTZ 1932), but after his next

field trip to the Nida area in 1925 (KREUTZ 1925, p. 63), he corrected that view and claimed that the crystals were 1-2.5 m long (KREUTZ 1925, p. 64) although later (1929, 1930, 1932) he wrote that the intergrowths were over 2 m long.

[17] MOROZEWICZ (1931, p. 758) wrote that, according to ZEJSZNER (1861b) and KONTKIEWICZ (1882), *"crystals (...) are prisms, sometimes up to 3 m high, standing side by side parallel to each other, but always perpendicular to the layering of their substrate (...), so that the thickness of the whole bed sometimes equals the length of single individuals (Gorysławice, Wiślica)"* (underlining of the present author).

[18-19] In 1925 WEYBERG (p. 367) gave the value 3 m for the giant crystals from the Nida area, but in his later book (WEYBERG 1929), he repeated the 3 m size at p. 190, but added a 4 m size at p. 486.

[20] see footnotes 15-16

[21] SZAFER (1932, p. 301) wrote that *"the largest gypsum crystals in Europe"* crops out at Przęślin.

[22] HESSEL-ZALESKA (1950, p. 9, Ryc. 9) illustrated 3 m long specimens at Skorocice (photo by L. CHROBAK showing S. KREUTZ standing in front of the giant-crystal layer) but crystal sizes are poorly seen on the photo. MEDWECKA-KORNAŚ (1959, p. 180) believed that such 3 m long crystals were absent at Skorocice.

[23] AKERMAN & NIELUBOWICZ (1951, p. 540) wrote that the giant-crystal layer *"is composed of huge twinned crystals standing vertically, and the whole thickness of the layer is occupied by height of the particular crystals"*. According to them the thickness of the layer ranged from 1 to 5.0 m.

[24] JURKIEWICZ (1951, p. 258) wrote that the layer *"is built of giant crystals standing parallel to each other and perpendicularly to the layering"* and estimated the thickness of this layer as 4-5 m.

[25] GAWEŁ (1955) illustrated an unnamed gypsum outcrop with a note that the crystals were up to 4 m long, but in the main text he claimed that the giant intergrowths were 3 m long. This latter view was apparently accepted by him later (GAWEŁ & WÓJCIK 1974).

[26] SKALMOWSKI (1959, p. 8) claimed that *"thickness of that layer corresponds to the sizes of particular crystals"* and this thickness *"ranges from 3 to 6 m"*.

[27] NIELUBOWICZ (1961, p. 72) believed that thickness of the giant-crystal layer is the same as *"the height of particular, standing side by side, crystals"* and is from 1 to 6 m.

[28] WALA (1961, p. 278) noted that *"length of crystals coincides with thickness of the layer"* and estimated this thickness at 3-4 m.

[29] BOLEWSKI & TURNAU-MORAWSKA (1963, Ryc. 218; photo taken by A. WALA) illustrated an outcrop with 4-5 m long specimens situated, as they wrote, at Gacki. However, the photo is of a different locality: a spectacular monument of nature at Marzęcin, 5 km north of Gacki (Text-fig. 1B; compare BĄBEL 1991, Pl. I, Fig. 2). The crystals in this outcrop are maximum 2.4 m long.

[30] MAŚLANKIEWICZ (1970, p. 551, photo taken by him) illustrated two skeletal intergrowths from Gacki with the note that they were 3 m long. One intergrowth to the right, which extends out of the photo, seems to the present author to be at least 2.5 m long. However because a scale is absent in the photo and the accuracy of measurements is unknown it is possible that the crystals were significantly shorter than 3 m.

[31] KOZŁOWSKI & *al.* (1971) based on yet unpublished materials by KWIATKOWSKI.

[32] The photo of *"aggregates (...) more than 3 m long"* published by PAWŁOWSKI & *al.* (1979, Fig. 4) probably was taken at Łatanice (A. GĄSIEWICZ, personal communication, August, 2001). The present author did not recognize such long crystals on this photo and in any outcrops at Łatanice.

[33] Real ca 2.7 m size (KASPRZYK 1993b, Fig. 9) was inaccurately measured and approximated to 3 m.

[34] Based on this author's observations at Bogucice-Skałki.

[35] RUTKOWSKI (1986, p. 47) stated that *"crystal length, which equals the thickness of the layer, is 3.5-5 m"*.

[36] The gypsum crystals *"are considered as the largest in Europe and probably also on Earth"* (CUKIERSKA 1999, p. 16).

Erratum:

In the article “The largest natural crystal in Poland”, *Acta Geologica Polonica*, Vol. 52 (2002), No. 2, pp. 251-267, on the page 258, the size of the specimen from Buraitotto is incorrect.

The first sentence of the second paragraph should read: “The largest known evaporite gypsum twins include: the 6 m long specimen from Buraitotto, SE Favara in Sicily (RICHTER-BERNBURG 1973), and 4.5 m long twins cropping out E of Eledhiou in Cyprus (ROBERTSON & *al*. 1995, p. 239).”