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THE CONTRIBUTION OF STANISŁAW DŻUŁYŃSKI TO FLYSCH SEDIMENTOLOGY: A 'WESTERN' PERSPECTIVE[1]

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Abstract: In his ground-breaking research on the sedimentary structures of turbidites, Stanisław Dżułyński demonstrated and took to new levels of accomplishment the defining attributes of the Kraków School of flysch sedimentology established by Marian Książkiewicz at the Jagiellonian University. These attributes included a meticulous approach to fieldwork, the ability to recognize the scalar and vector relationships of diverse sedimentary features, a working knowledge of several languages, a capacity to describe systematically structures that had previously received scant attention in the world literature of geology, and innovation in the transfer of scientific knowledge. Dżułyński also added elements that were distinctively his own: a highly inventive approach to the replication of turbidite sedimentary structures in laboratory flumes, an openness to new ideas, boundless enthusiasm for his chosen field, and an exuberantly outgoing personality. In spite of worldwide recognition for his numerous and wide-ranging achievements in geology, he viewed himself first and foremost as one of the senior students of Marian Książkiewicz. In this role, Dżułyński utilised every opportunity to present with great insight and objectivity the work of the Kraków School, enthusiastically shared his extensive knowledge of sedimentology with experienced colleagues and new acquaintances alike and, in particular, gave generous encouragement to young researchers.

Key words: sedimentary structures, turbidites, Carpathian flysch, laboratory flume studies, knowledge transfer.

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INTRODUCTION

In a recent account of the evolution of clastic sedimentology (Okada & Kenyon-Smith, 2005), the work undertaken on the Cretaceous–Palaeogene flysch in the Polish Carpathians by Professor Marian Książkiewicz, his students and colleagues during the 1950s and 1960s is cited as a seminal example of basin analysis in ancient deepwater sequences. The same authors also stress the major contribution of Stanisław Dżułyński and his collaborators to the study of the sedimentary structures associated with turbidites during those decades. These accolades recognise the innovative nature of the work carried out by the group led by Professor Książkiewicz (that may be termed 'the Kraków Flysch School'[2] during the formative years of sedimentology and they also confirm the eminent international status of the Kraków School. Stanisław Dżułyński was a leading member of this group (that also included, amongst others, K. Birkenmajer, A. Radomski, A. Ślączka and R. Unrug) and he was especially adept in communicating the stream of ideas and observations that flowed out of Kraków at that time. Moreover, despite physical and political constraints and barriers that are almost unimaginable in this age of instantaneous electronic communication, he found a particu-

1 This paper is an amplified version of an extended abstract presented at the *In Memoriam* meeting held on 7th October, 2006 in the Jagiellonian University, Kraków, to commemorate the lives and contributions of Professor Marian Książkiewicz and Professor Stanisław Dżułyński

2 Those involved in the Kraków Flysch School, as informally defined here, included at various times some staff from the Geology Department of the Jagiellonian University and the Academy of Mining and Metallurgy, as well as the Kraków branches of the Polish Academy of Sciences, the Geological Institute, Carpathian Branch, and also from the Polish oil industry.

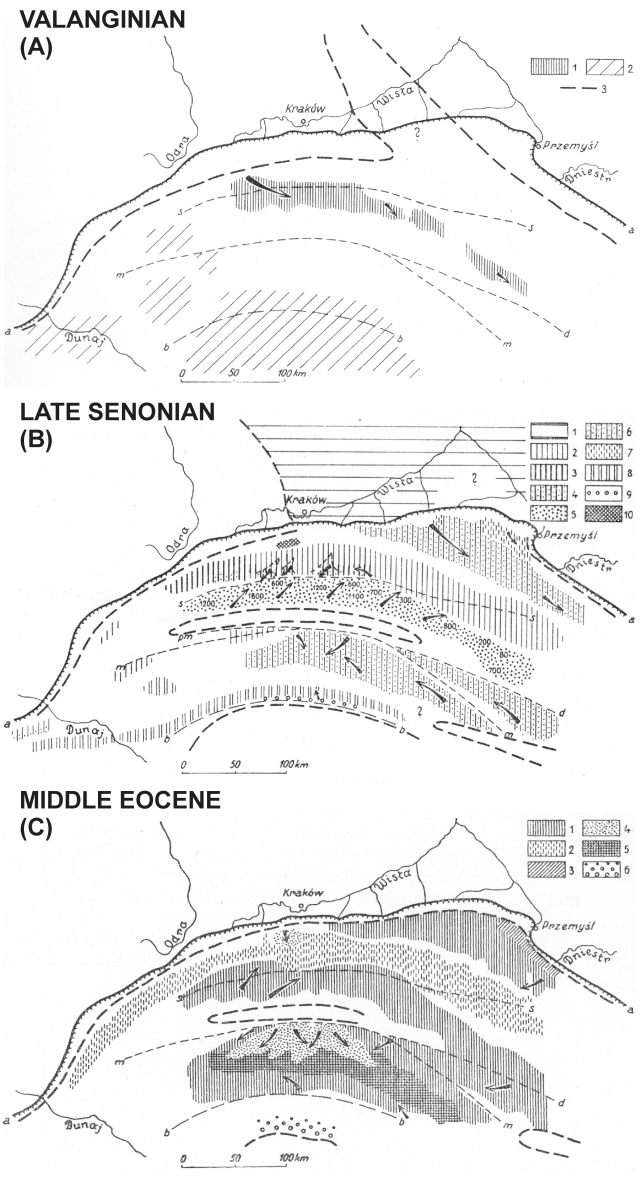


Fig. 1. Basin analysis of the Cretaceous–Palaeogene Carpathian flysch south of Kraków (*from* Książkiewicz, 1960)

larly receptive audience in the contemporary English-speaking world.

Thus the aims of this paper are: (i) to summarise (from the perspective of the western geoscience community) the contributions of the Kraków School to our understanding of flysch and turbidites and to assess the particular contributions of Stanisław Dżułyński in that context; (ii) to document (using the recollections of British and American contemporaries) the traits of character, attitude and experience that enabled Dżułyński to achieve so much in his scientific endeavours and to leave such a distinctive and memorable impression on those who knew him; and (iii) to reflect on the factors governing the effective transfer of scientific knowledge that can be gleaned from the success of Książkiewicz, Dżułyński and the Kraków Flysch School in influencing contemporary geoscience.

THE "FLYSCHERMEN" OF KRAKÓW

The subdiscipline of *clastic sedimentology* emerged from its parent disciplines of petrology and stratigraphy in the two decades following the Second World War. Its rapid growth coincided with the development of several radical concepts, paradigms and technical innovations, including the notion of frequent gravity flows in the rock-record, the widespread adoption of palaeocurrent analysis and the rediscovery (by western geologists) of the Waltherian concept of sedimentary facies. Simultaneously, the actualistic approach to understanding the genesis of ancient deposits, both through detailed observation of modern sedimentary processes and by means of qualitative and quantitative experiments, greatly enhanced our understanding of the structures, compositions, textures and sequential arrangements (i.e. the lithologies) observed in ancient, clastic sediments.

In this ferment of geoscientific enquiry the Kraków School first came to the attention of western geologists through the percipient observations and novel interpretations of flysch[3] sequences in the Polish Carpathians made by Marian Książkiewicz and his students from the late 1940s onwards. These provided Migliorini and Kuenen with vital field evidence to support their then-controversial conclusion that much of the classic Alpine flysch was the product of gravity controlled flows operating in relatively deep marine basins. Then, in a masterly synthesis of the Carpathian 'Geosyncline' (Książkiewicz, 1960) revealed to western geoscientists a vista of tectonically active basins, separated by internal cordilleras supplying vast volumes of coarse sediment, conveyed by turbidity currents that flowed both down marginal slopes and along the axes of basins (Fig.1). Over the succeeding two decades the basin analysis techniques devised and adopted by the Kraków 'flyschermen' were successfully applied throughout the Carpathian belt to elucidate tectono-sedimentary evolution, as exemplified in the Carpatho-Balkan Palaeotransport Atlas, edited by Ślączka (1976).

These contributions of the Kraków School to 'mega-sedimentology' were paralleled by a series of influential studies on the 'micro-sedimentology' of flysch deposits, concerned with the distinctive structures and textures found in these sediments. These topics had been touched upon by

3 The term *flysch* is used here in the sense adopted by eastern European geologists, i.e. as a type of lithofacies marked by the presence (and absence) of specific physical characteristics, including coarse/fine alternations, regular bedding, poorly sorted, clay-rich coarse units, sharp-based, often sole-marked sandy units, etc. (see Dżułyński, 1963, pp.82-83). It equates, broadly, with the 'greywacke' lithofacies of European Palaeozoic terrains.

Książkiewicz in the early 1950s (e.g. Książkiewicz, 1951, 1954) and Stanisław Dżułyński soon became a major player in this aspect of turbidite sedimentology, with a series of publications (many in collaboration with both Polish and foreign co-workers) on the great variety of sole-marks and internal (especially deformational) structures found in such sequences. Thus began Dżułyński's lifelong fascination with these intriguing and often aesthetically pleasing features. The unique collection of such structures now housed in the Jagiellonian University attests to Dżułyński's absorbing interest in this topic and reflects the massive expenditure of intellectual, physical and logistical effort demanded by this interest.

The priority for this type of study was to assist the Carpathian basin analysis programme by identifying which structures were useful for determining palaeocurrents and palaeoenvironments (and how the orientation of structures was related to the generating palaeoflows). The use of these structures for determination of way-up in structurally complex terrains was a further important application. However, Dżułyński and other colleagues soon became interested in the classification of these features and in elucidating their precise mode of origin.

The impact of this 'smaller-scale' approach to flysch sequences is evident in several important modifications of the infant 'turbidite paradigm' (Walker, 1973) that were introduced through the influence of the Kraków School. For example, the concept of *fluxoturbidites* (regarded as a related, but distinctive product of gravity-controlled flow) was first formally defined by Dżułyński *et al.* (1959), using examples from the flysch of the Outer Carpathians. This was some 3 years before the formal definition of the ideal turbidite sequence (Bouma, 1962) – and heralded the plethora of gravity driven mechanisms and deposits that are currently invoked in describing so-called turbidite successions (cf. Shanmugam, 2000; Dasgupta, 2003; Baas, 2005; etc.). Furthermore, the careful and astute observations of Kraków sedimentologists in the Krosno beds and other Carpathian flysch formations (e.g. Dżułyński & Ślączka, 1958), demonstrated that different transport directions could be recorded within a single turbidite bed, and thus provided compelling evidence for the complexity of the processes involved in the transport and emplacement of many such units (see also Kelling, 1964; Scott, 1966; Walton, 1967).

Additionally, through Dżułyński and his collaborators, the Kraków 'flyschermen' were amongst the first to successfully reproduce in careful and ingenious experiments many types of sole mark and internal structure (e.g. Dżułyński & Sanders, 1962; Dżułyński & Walton, 1963; Dżułyński, 1966; Dżułyński & Simpson, 1966a, b; Anketell & Dżułyński, 1968a, b, etc.). In recent years these experiments have been criticised for being non-quantitative or inaccurately scaled. However, at that time they were of great significance, not only because they helped to validate deductions made from field observations but also because many experiments yielded new and unexpected insights into the behaviour of suspension flows and of rapidly deposited sediment.

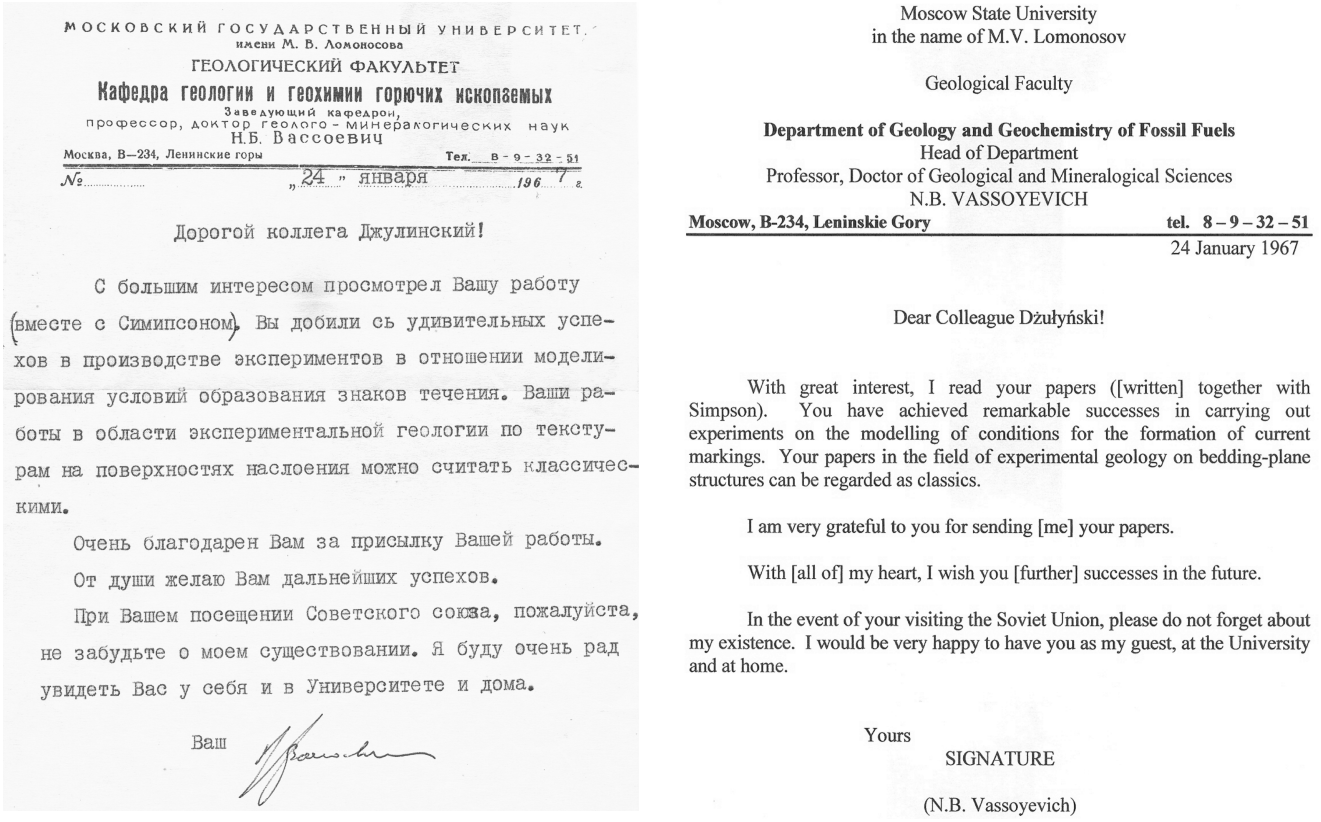
An example of the validation scenario is the laboratory study of the relationship between flute formation and tool impingement on a cohesive mud bottom (Dżułyński & Simpson, 1966a), which supported field observations, such as those of Simpson (1970, pp. 254–259), documenting the close associations of flute moulds and tool markings on particular sandstone soles. The experiments of Dżułyński and Radomski (1966) on the bedding disturbances produced by the impact of dense suspensions on horizontal sedimentary layers provide abundant illustrations of the unexpected insights outcome.

One important question concerning the Kraków Flysch School remains to be addressed. Given the endemic shortage of resources, restrictions on travel and relatively primitive communications that prevailed in eastern Europe during these early years of clastic sedimentology, how was it possible for a group of comparatively young Polish geologists to exert such significant influence on contemporary, western geoscientific thinking – especially when much of their work was published in Polish journals?

Our collective experience suggests several factors that may have contributed to this outcome. Firstly, the leadership, wide-ranging knowledge and accumulated experience of Marian Książkiewicz were critical in assembling and nurturing the research potential of this group. So, too were his assiduous efforts to make and maintain personal contact with leading geologists in all parts of the globe. One of us (FS) was a postgraduate student of Marian Książkiewicz in the 1960s and recalls how he and his Kraków colleagues were fully aware of the advances being made by western sedimentologists such as Kuenen, Crowell, Rich, A. J. Smith, etc., but also were familiar with the previous and contemporary work of Soviet geologists, such as N.B. Vassoyevich, A. B. Vistelius and O. S Vyalov, whose innovative sedimentological studies were scarcely known in the west (Fig. 2).

Also important was facility in languages. Książkiewicz had an excellent grasp of English – honed during his wartime sojourn in Britain – and of several other languages. Indeed, most members of the Flysch School were fluent in two or three languages in addition to their native tongue. Describing 'new' sedimentary structures demanded agility in the use of language (both English and Polish). The same could be said of technical terms, originally coined in English, which had to be rendered into Polish. Dżułyński displayed ingenuity in responding to both kinds of challenge. Furthermore, this linguistic facility enabled many members of the School to have direct, personal, contact with like-minded geologists, not only those from western countries and the Soviet Union, but also those from neighbouring eastern European states, and especially from the Balkano-Carpathian region. Such informal contacts were vital in the transfer of knowledge, especially in the burgeoning field of sedimentology, and often resulted in highly charged discussions that mobilised every linguistic resource available to each of the participants!

Another source of strength for the Kraków group was the support of national organisations such as the Polish



МОСКОВСКИЙ ГОСУДАРСТВЕННЫЙ УНИВЕРСИТЕТ
имени М. В. Ломоносова
ГЕОЛОГИЧЕСКИЙ ФАКУЛЬТЕТ
Кафедра геологии и геохимии горючих ископаемых
Заведующий кафедрой,
профессор, доктор геолого-минералогических наук
Н.Б. Вассоевич
Москва, В–234, Ленинские горы Тел. В-9-32-51
№ „24" января 196 7 г.

Дорогой коллега Джулинский!

С большим интересом просмотрел Вашу работу (вместе с Симипсоном). Вы добили сь удивительных успехов в производстве экспериментов в отношении моделирования условий образования знаков течения. Ваши работы в области экспериментальной геологии по текстурам на поверхностях наслоения можно считать классическими.

Очень благодарен Вам за присылку Вашей работы.

От души желаю Вам дальнейших успехов.

При Вашем посещении Советского союза, пожалуйста, не забудьте о моем существовании. Я буду очень рад увидеть Вас у себя и в Университете и дома.

Ваш

Moscow State University
in the name of M.V. Lomonosov

Geological Faculty

Department of Geology and Geochemistry of Fossil Fuels
Head of Department
Professor, Doctor of Geological and Mineralogical Sciences
N.B. VASSOYEVICH
Moscow, B-234, Leninskie Gory **tel. 8 – 9 – 32 – 51**
24 January 1967

Dear Colleague Dżułyński!

With great interest, I read your papers ([written] together with Simpson). You have achieved remarkable successes in carrying out experiments on the modelling of conditions for the formation of current markings. Your papers in the field of experimental geology on bedding-plane structures can be regarded as classics.

I am very grateful to you for sending [me] your papers.

With [all of] my heart, I wish you [further] successes in the future.

In the event of your visiting the Soviet Union, please do not forget about my existence. I would be very happy to have you as my guest, at the University and at home.

Yours
SIGNATURE

(N.B. Vassoyevich)

Fig. 2. Letter to Dżułyński (in Russian, with English translation by F. Simpson) from the prominent Soviet geoscientist, Prof. N. B.Vassoyevich, illustrating the important role of the Kraków school in bridging the scientific divide between east and west in that era

Geological Society and Polish Academy of Sciences, in facilitating the international transfer of knowledge on new trends in sedimentology during the 1950s and 1960s. In traditional Polish fashion, such support was commonly expressed in generous hospitality, cementing scientific relationships and ensuring continued close communication with overseas colleagues, as many foreign geologists will gladly affirm.

Moreover, at a time when access to field transport by Polish geologists was highly restricted, the geographical location of Kraków was clearly advantageous for research on the Carpathians, although ingenuity and initiative was also required to maximise this advantage. Thus, the highlight of a visit for foreign geologists often was a field trip to the Carpathians led by Professor Książkiewicz. He would obtain a car and driver from the University or the Polish Geological Institute and would explain at length how the rocks of a particular outcrop fitted into the evolving picture of Carpathian geology. What these visitors seldom realised was that at some locations, the famous Professor was making detailed field notes for the first time, and might not have even seen the outcrop before. This was simply Książkiewicz making the best use of scarce transportation!

In retrospect, it is evident that Książkiewicz and his students were instinctively putting into practice the principles of knowledge transfer, as applied to the dissemination of research results, and recently codified by Woodfield (2003) (Fig. 3).

Knowledge Transfer Principles
(Research Dissemination Guidelines)

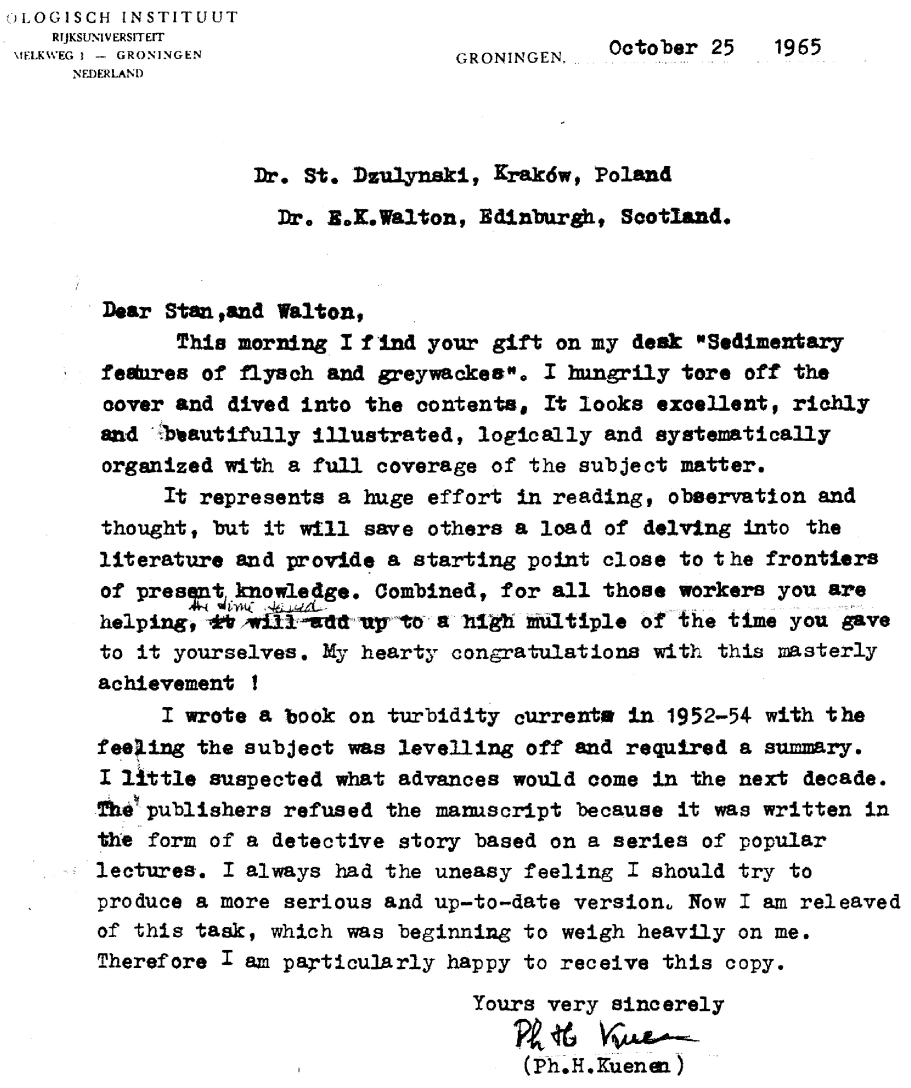
1. **Strategic Approach**
2. **Knowing Target Audience**
3. **Hitting the Target**
4. **Sustainable Dissemination**
5. **What was Achieved?**

(Woodfield, 2003)

Fig. 3. The principles of knowledge transfer, in the context of dissemination of research, as defined by Woodford (2003)

Specifically, the *Strategic Approach* of the Kraków School required prior acquisition of the language skills mentioned earlier, facilitating their active participation in international conferences and expanding their international outreach at a time when political conditions were inimical to frequent travel to foreign destinations. Members of the School demonstrated their *Knowledge of the Target Audience* through their frequent collaboration with co-workers

from both East and West, which provide insights into the latest and most relevant advances in geoscience from both spheres and enabled them to influence and implement the design of novel scientific projects. Moreover, their 'multi-channel' approach, included publication of their results in refereed journals of both East and West and oral presentations at both Polish and international conferences (and, especially, participation in international field-meetings), ensured achievement of the aim of *Hitting the Target*. The goal of *Sustainable Dissemination* was achieved by members of the School primarily through their networking activities with research groups and individuals in Poland and abroad, which ensured that the hard-won research skills, techniques and concepts they had acquired were widely recognised and adopted for many years. (Dżułyński acknowledged that visits to Kraków by western geologists such as Kuenen, Walton, Stanley and Smith during the 'isolation years' in the fifties and early sixties were an important source of stimulation, encouragement and scientific validation). Moreover, the methodical and systematic collecting of sedimentary structure specimens, many now displayed in the UJ-ING Museum, yielded an almost unique physical expression of the observations and interpretations made by the School through more than half a century. Finally, assessment of *What Was Achieved* by the Kraków School in the context of research dissemination depends to some extent on the perspective of the observer. From the viewpoint of the members of the School, they could justifiably point to the high and distinctive profile in the global geological community that was gained and sustained for many years by their contributions to flysch research, in the face of formidable economic and political obstacles. From the perspective of international geoscience it can be argued that the School's major achievement was to demonstrate how the use of different, but mutually supportive, approaches to the investigation of geological processes could expedite the transition from hypothesis to accepted theory. A pertinent example is the integration of detailed field observations of flysch strata and their structures with flume experiments on turbidity flows.



OLOGISCH INSTITUUT
RIJKSUNIVERSITEIT
MELKWEG 1 – GRONINGEN
NEDERLAND

GRONINGEN, October 25 1965

Dr. St. Dzulynski, Kraków, Poland
Dr. E.K.Walton, Edinburgh, Scotland.

Dear Stan,and Walton,

This morning I find your gift on my desk "Sedimentary features of flysch and greywackes". I hungrily tore off the cover and dived into the contents, It looks excellent, richly and beautifully illustrated, logically and systematically organized with a full coverage of the subject matter.

It represents a huge effort in reading, observation and thought, but it will save others a load of delving into the literature and provide a starting point close to the frontiers of present knowledge. Combined, for all those workers you are helping, it will add up to a high multiple of the time you gave to it yourselves. My hearty congratulations with this masterly achievement !

I wrote a book on turbidity currents in 1952-54 with the feeling the subject was levelling off and required a summary. I little suspected what advances would come in the next decade. The publishers refused the manuscript because it was written in the form of a detective story based on a series of popular lectures. I always had the uneasy feeling I should try to produce a more serious and up-to-date version. Now I am releaved of this task, which was beginning to weigh heavily on me. Therefore I am particularly happy to receive this copy.

Yours very sincerely
Ph H Kuen
(Ph.H.Kuenen)

Fig. 4. Laudatory letter written by Philip Kuenen to Dżułyński and Walton, acknowledging the receipt of their book "Sedimentary Features of Flysch and Greywackes" (1965)

THE SCIENTIFIC CONTRIBUTIONS OF STANISŁAW DŻUŁYŃSKI

Stanislaw Dżułyński's initial researches were concerned with shallow marine, carbonate-dominated sequences and he later achieved distinction in the study of carbonate-hosted ore-deposits and karst geology. However, there is no doubt that it was his contributions to the nascent field of turbidite sedimentology that first brought Dżułyński to the attention of western scientists and cemented his international reputation. In his contribution to the In Memoriam volume (Gradziński & Kędzierski, 2006), Dan Stanley has furnished a vivid example of the high international reputation, which Dżułyński enjoyed in the halcyon era of turbidite/flysch research, citing how his unexpected and stage-managed intervention on the question of 'fluxo-turbidites' at Stanley's public thesis defence in Grenoble in 1961 silenced the opposition of vocal traditionalists and ensured that

Fig. 5. Stanisław Dżułyński (in 1996) contemplates his life-spanning collection of turbidite sedimentary structures in the Museum of the Institute of Geological Sciences of the Jagiellonian University, Kraków. (Photo by F. Simpson)

Stanley was awarded his doctorate (Stanley, 2006, p. 116). The invitation to Dżułyński in 1972 to succeed the legendary Francis J. Pettijohn at Johns Hopkins University in Baltimore, USA (Karcz, 2006), is further proof – if any were needed – of the high international esteem which he enjoyed.

For western scientists, Dżułyński's most distinctive sedimentological legacy is to be found in the lovingly compiled and lavishly illustrated monographs of erosional and deformational sedimentary structures published in 1963, 1996 and 2001, together with the classic synthesis volume on turbidites by Dżułyński & Walton (1965). These publications continue to be cited up to the present, but perhaps the most telling tribute was provided by the father of turbidites, Philip Kuenen. On receiving a copy of their 1965 synthesis, Kuenen wrote in a private letter to Dżułyński and Walton (Fig. 4).

"[The book] ... looks excellent, richly and beautifully illustrated, logically and systematically organised, with a full coverage of the subject matter. My hearty congratulations with this masterly achievement".

The unique collection of sedimentary structure specimens, hard-won from the outcrop or painstakingly extracted from the floor of tank and flume by Dżułyński, his students and colleagues and now housed in the Geological Museum of the Jagiellonian University (Dżułyński, 2001), represents a further tangible tribute to his scientific skills – and also to his stamina, dogged persistence, and determination (Fig. 5).

Less conspicuous, but equally significant, contributions by Dżułyński to sedimentological science are the general concepts and models he introduced or modified through his researches into the forces responsible for the creation and preservation of erosional and especially deformational structures. For example, even in his early publications (and at a time when the mere presence of flutes or grooves on a sandstone sole was widely regarded as proof of genesis from deepwater turbidity currents), he stressed the importance of distinguishing process from environment, pointing out that many so-called turbidite structures occur in sediments formed under a wide range of environmental conditions (fluvial, neritic, etc.: cf. McKee, 1954; Cummins, 1957). Again, the description and discussion of lateral changes in the character of 'flysch (turbidite) facies' given in Dżułyński and Smith (1964) and in Dżułyński and Walton (1965) and partly derived from experimental observations, demonstrated how both mean grain-size and internal sequences of structures change along the path of suspension-flows, and thus anticipated the concept of proximality/distality promulgated later by Walker (1967).

Dżułyński also demonstrated that at least some of the processes observed in experiments (such as vertical displacements resulting from sediment-density contrasts) operate at widely different scales and in a wide range of geological materials and environmental settings Thus, polygonal 'involutions' at greatly varying scales may be produced in rapidly deposited sediments, periglacial soils and igneous bodies, while longitudinal ridges may be produced at the interfaces between clay and sand units or on the walls of basaltic dykes (Dżułyński, 1996). In addition, the experiments conducted in collaboration with Walton, Simpson, Anketell and others convinced Dżułyński that:

"genetically consanguineous sedimentary structures are sometimes divided by arbitrary classifications ... and many of the [wide spectrum of erosional and deformational] structures may be attributed to [different stages of] the same or similar formative process" (Dżułyński, 1996, p.137).

In today's esoteric world, where sedimentologists struggle to understand the nature and effects of 'flow transformations' and to distinguish the ancient deposits of 'classical', high-concentration or dilute turbidity currents, de-

Fig. 6. Dżułyński (in foreground, with woolly cap and ever-present pipe), with colleagues (including A. Radomski and A. Ślączka) and students on field-trip to Carpathians in 1966. (Photo by F. Simpson)

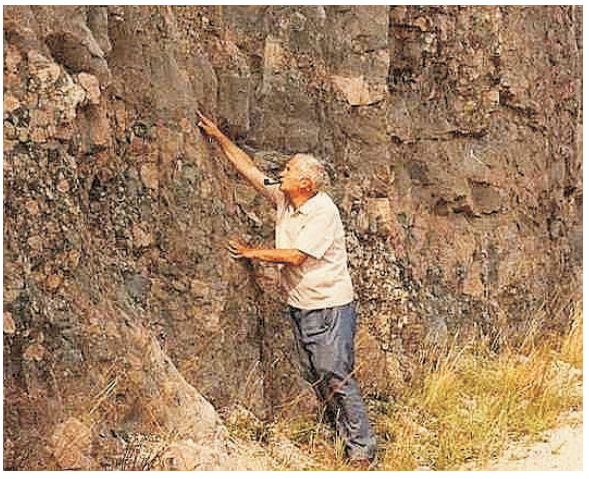


Fig. 7. Dżułyński (still attached to pipe) getting to grips in 1991 with an exposure of the Huronian Gowganda Formation, Ontario, Canada. (Photo by F. Simpson)

bris, grain and other sediment-gravity flows, or to identify contourites, tempestites, tsunamites, hyperpycnites and other 'event units', these are prescient and salutary comments to consider!

STANISŁAW DŻUŁYŃSKI – THE PERSON

"Professor Marian Książkiewicz and Professor Stanisław Dżułyński were exceptional individuals, outstanding scientists, towering figures in the field of sedimentology, who made lasting contributions to Polish geology. They differed in physical appearance: Professor Książkiewicz was of slim physique, held himself very straight, walked in measured strides and dressed in a rather conservative manner, while Miś ('Little Bear') Dżułyński was burly, ... ambled in a leisurely fashion and tended to wear informal clothes. Both were of great intellectual depth and showed immense personal charm, but they interacted with others in very different ways: Professor Książkiewicz used words economically and with authority and paid great attention to the formal aspects of conversation, but with a fleeting smile that truly could light up a room; Miś spoke with great eloquence and in a boisterous manner, often in a cascade of words and expressions, culled in part from Poland's literary classics, and spared no effort to put his audience at ease".

This graphic word-picture painted by Frank Simpson strikes a strong affirmative chord with those geologists from western countries who were privileged to know these two outstanding geologists. The last sentence also rings true since those who knew Stan quickly became aware of his love for, and deep knowledge of classical Polish literature. This knowledge came to Dżułyński's aid in unexpected ways. For example, when he and Czesław Żak (1960) created the Polish expression "pogrązy" for load-casts from the verb "pogrążać" or "pogrążać się", meaning "to sink", and then with Janusz Kotlarczyk (1962) the term "pogrzęźnięte pręgi faliste (riplemarki)" for "load-casted ripples", from "grzęznąć", also meaning "to sink" … notably where the wheels of a stagecoach became stuck along a muddy track!

With regard to Dżułyński's scientific attributes, the personality traits that impressed western co-workers most forcefully were his enthusiasm, observational abilities, dedication, ingenuity and, of course, his forceful and passionate debating style. His enthusiasm and keen observational skills were manifested in the way he crawled over outcrops – even those he had visited many times – inspecting each tiny unit and always finding some structure or feature that somehow had previously escaped his scrutiny, or that of his guide (Figs 6 and 7).

Simpson recalls that during their collaboration in the mid-1960s, Dżułyński very much warmed to his role of a senior student of Professor Książkiewicz, giving guidance to the newly arrived novice. Dżułyński was a veritable mine of information about the work of the Kraków School and eagerly responded to questions about its achievements with great insight and objectivity. He tirelessly shared his extensive knowledge of sedimentology and his very large collection of sedimentological reprints – sent to him by authors, not only in the Eastern Bloc, but also representing many nations of the West – with new acquaintances, as well as with colleagues of longer standing. Like his own mentor, Professor Książkiewicz, he generously gave his time and energy to boosting the knowledge and confidence of younger researchers. His approach to providing encouragement frequently involved taking a "contrarian" stance, designed to generate strong discussion. Highly technical conversations would become increasingly animated from the moment Dżułyński would declare, "Nic podobnego!" ("Nothing of the sort!") These were recurring elements of a friendship that was to last for more than thirty-five years. Dżułyński's affinity with young researchers remained undiminished into old age, as attested by Dr. Huriye Demircan, a young Turkish trace-fossil specialist, who visited Kraków between

Fig. 8. "Beside every great man ….. ! ! Dżułyński and his wife Krystyna, in front of their home in Kraków (1996). (Photo by F. Simpson)

1996 and 2001. She fondly recalls frequent invitations to dine with the Dżułyński's, and how amazed she was at the lack of pretension of this famous geologist, together with his generous spirit and the still lively and enquiring mind that engendered many lively discussions.

As indicated earlier, his dedication (some might say, obsessiveness!) and ingenuity are most effectively expressed in his monographs and in the unique collection of structures now on display in the Jagiellonian University These traits also can be illustrated by two anecdotes. Mike Anketell came from Manchester University to Kraków on several occasions in the late 1960s to undertake experiments with Dżułyński on depositional systems displaying reversed density gradients. In these experiments they were using mixtures and suspensions of plaster of Paris, clay, silt, etc. but, because there was little visual contrast between the sediment layers, it was difficult to image the resulting structures. On one visit, Anketell recalls, he brought with him a kilo or two of premium ground coffee – a precious commodity in Poland during that period of austerity. However, the coffee never reached Krystyna, Dżułyński's patient and ever-supportive wife (Fig. 8.), because Stan had a 'Eureka moment', deciding as soon as he saw it, that this coffee,

Fig. 9. One of the "mini-aquarium" tanks, in which Dżułyński conducted many of his experiments to produce deformational structures, now displayed in the Museum of the Institute of Geological Sciences of the Jagiellonian University, Kraków. The tank is approximately 65 cm long and 15 cm wide. (Photo by G. Kelling)

scattered on to the newly deposited sediment, was the perfect material to provide the visual contrast needed to demonstrate the deformations!

On another occasion Walton and Dżułyński were conducting their seminal tank-experiments in Edinburgh on the down-flow sequence of erosional structures. Dżułyński was, of course, an inveterate pipe-smoker and used more matches than tobacco – probably because he got so lost in thought he forgot to puff on his pipe! One day he was lighting his pipe near a tank containing a bed of clay that had been stained with potassium permanganate. A thin, cohesive skin had formed on the clay surface and as Stan idly wafted a match-stick in the tank he suddenly shouted across the lab. "*Hey, Ken, look – a chevron mark and a cut chevron*"! The movement of the match had rucked up the clay skin. When the match was moved slightly above the clay surface a simple chevron was produced; when the match cut into the surface a small groove resulted, creating a cut-chevron!

In a sense, however, such anecdotes conceal Dżułyński's remarkable skill as an expermentalist. Dan Stanley has recounted (Stanley, 2006) his incredulity as he watched 'Miś' Dżułyński " … placing his hand in some old rusty cans and jars, pulling out a leaf there and … a fish bone there … to prepare his special concoction as only a magician could and … creating beautiful sole-marks ... in an apparatus resembling a small, very dirty aquarium with a partially broken glass pane" (Fig. 9)!

To his colleagues from the west Dżułyński was a generous friend, serious and socially aware, whose total dedication was carried with a lightness and a ready humour. He could be positive, even aggressive, in debate but also sensitive and considerate. However, he had no time for mere show and ostentation and was impatient with those who were less than totally devoted to their science – the poseurs and the 'apparatchiks'.

Conversely, wherever he travelled, Dżułyński valued and cultivated contact with the peasant and the working man. Whilst in Edinburgh in the 1960s, he found accommo-

dation in Portobello, then a working class part of the city, and each day he walked the 5 km to the Geology Department. He would stop working only when he felt hungry and walked home again in the late evening, often stopping on the way at a rather run-down, but boisterous, pub for a drink and a chat with the workers. He said it reminded him of home! Again, while working at the U.S. National Museum, Washington, D.C., in the late 1960s (a time when civil unrest and violent crime were rife in that city) Bob Neuman and Dan Stanley, his hosts, were horrified to discover that Stan had moved out of his Museum-approved accommodation to a tiny room in a district, near the Capitol building, that was one of the most crime-ridden areas of the city and almost exclusively inhabited by African-Americans. When taxed with the dangers in which he was placing himself, Dżułyński retorted that his black neighbours knew he was a Pole and thus was a member of an oppressed minority and too poor to be worth robbing. Besides, he enjoyed living there!

Dżułyński customarily exuded an air of strength and calm assurance that was disturbed only on rare occasions. During the 1967 International Sedimentological Congress held in Reading and Edinburgh (U.K.), he came to Walton in a clearly distressed state and said "*Ken, I am a lost person – I have lost my papers. I am a Non-Person, I have no identity and I desperately need your help*". At first, Walton thought he was joking but then realised that Dżułyński was seriously concerned. Although the situation was quickly resolved, this incident was a powerful reminder of the toll of cumulative stress exacted by living for decades under conditions of restriction and oppression.

To scientists from the West, despite their very different appearance, personalities and mannerisms both Professors Książkiewicz and Dżułyński seemed to embody that combination of personal qualities that is often portrayed as typically Polish, namely inventiveness and flair, the determination to succeed in difficult circumstances, a self-deprecatory view of their achievements and, above all, the ability to find humour in adversity. Dżułyński's brief, hand-written note to Simpson, on a reprint of one of his later obituaries of Marian Książkiewicz (Fig. 10), speaks volumes about the writer. It demonstrates that even at the height of his success in research and international fame, in spite of all he had achieved, Miś still saw himself as one of the senior students of the man, who had been his mentor and friend for so many years. This fact in itself indicates an uncommon degree of humility and humanity in one of sedimentology's most influential figures.

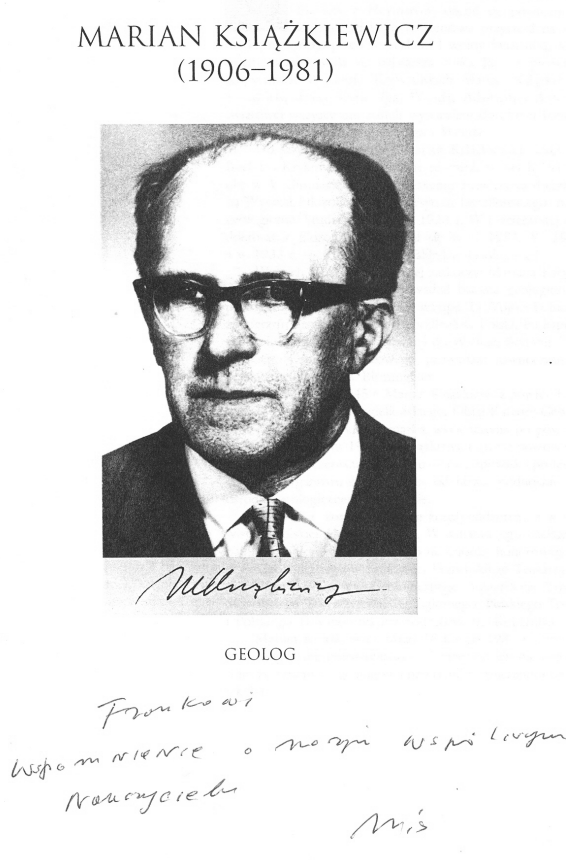


Fig. 10. The frontispiece of a reprint of his obituary of Professor Książkiewicz, sent by Dżułyński to Frank Simpson, with its inscription: "Frankowi. Wspomnienie o naszym Wspólnym Nauczycielu. Miś". ("To Frank. A reminiscence about the teacher we shared. Miś")

CONCLUSIONS

To summarise, the great advances in Carpathian geology and turbidite sedimentology made by Marian Książkiewicz, Stanisław Dżułyński and their colleagues, achieved under adverse conditions, contributed very significantly to the rapid growth of basin analysis techniques and of turbidite sedimentology. For this reason alone they fully merit the recognition and approbation of the geoscientific world. Moreover, the emphasis placed by Professor Książkiewicz on the dissemination of research ideas and results through personal interaction and high-quality publications, while apparently a simple strategy, was, in its time, both innovative and cost-effective. Indeed, it continues to be highly relevant and widely applicable even in our era of advanced communication technologies and sophisticated information management techniques.

On a more personal note, those of us who were privileged to know these great geologists continue to cherish not only their scientific skills and scholarly dedication but also the generous humanity that guided their lives and illuminated ours.

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