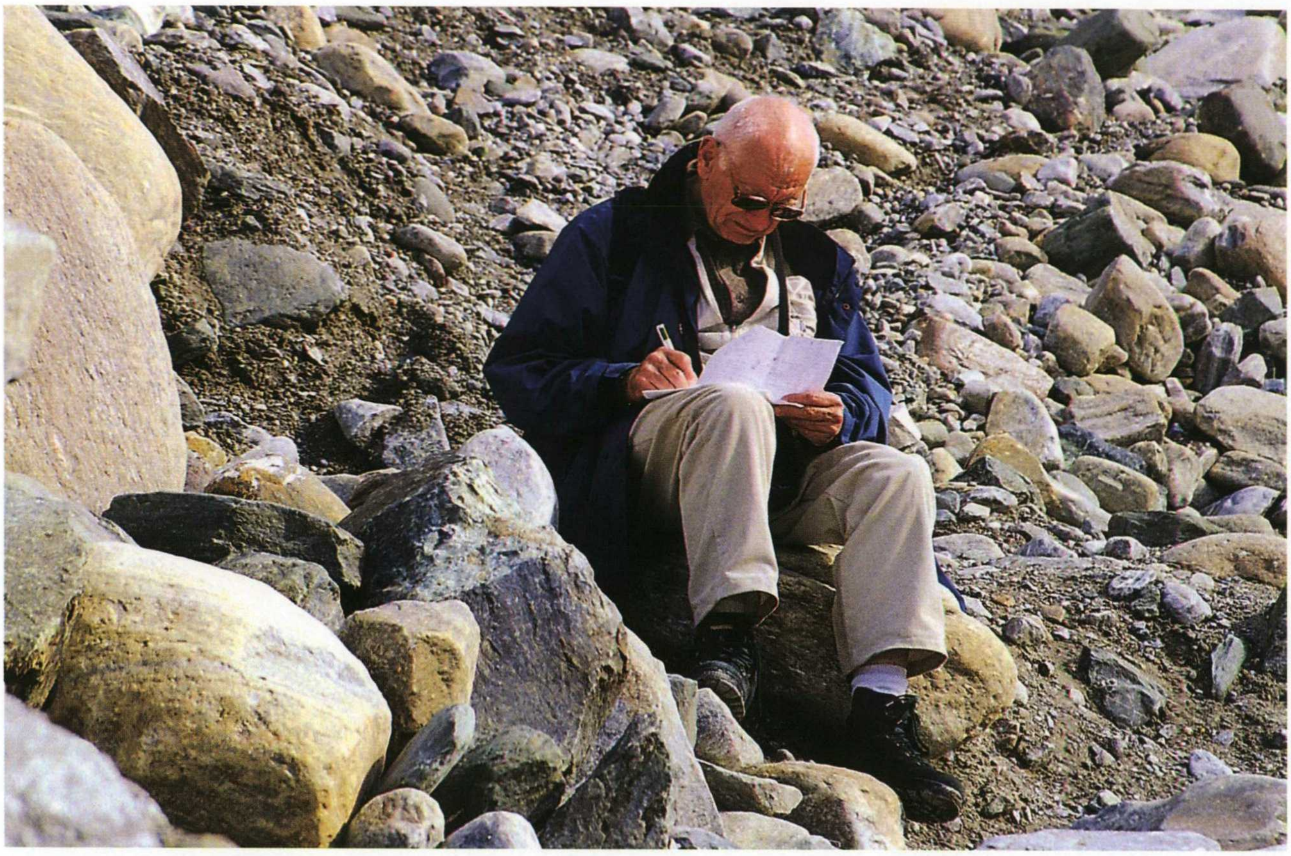
Interview with Prof. Roman Teisseyre

Without Compulsion

Marek Górski



The dislocation theory developed by Prof. Roman Teisseyre elegantly explains how an earthquake is initiated in its focus (hypocenter)

Academia: It seems we can safely call you one of the discoverers of our contemporary grasp of earthquakes? I mean of dislocation theory.

Professor Roman Teisseyre: There is some exaggeration in that assertion: other researchers also dealt with the theory somewhat, so I was not alone. Our dislocation theory has above all explained the problem of how seismic energy gets released. The earthquake process is one in which the structure of the rock medium becomes destroyed; it is very difficult to capture in mathematical and physical terms, since the dynamics are accompanied by a drastic change in the rock's properties. Later I worked on the fundamental thermodynamics of earthquakes, and recently I have studied certain new aspects of earthquakes - rotation's role as an independent motion in the process of destroying material, in particular during the sort of process that occurs in an earthquake focus. Although these "new" aspects are also in a sense old, having been considered by seismologists back when the science was first being established.

Can you explain to a layman what rotational waves are?

Probably everyone has heard of longitudinal and transverse seismic waves, which involve linear displacements. But transverse waves are also always accompanied by rotational waves. For longitudinal waves there is no rotation. An important new discovery is that in an earthquake's hypocenter, meaning where material is destroyed, such rotation is actually of great significance. That is what my research has shown. Compression stresses within the focus give rise to induced shear stresses, which are associated with dislocation arrays. That leads to the local microfracturing of material, and then to its fragmentation. An important role in synchronizing these processes is played by the rotational waves which are created and propagate at the same time.

Does that manifest itself in some way on the surface?

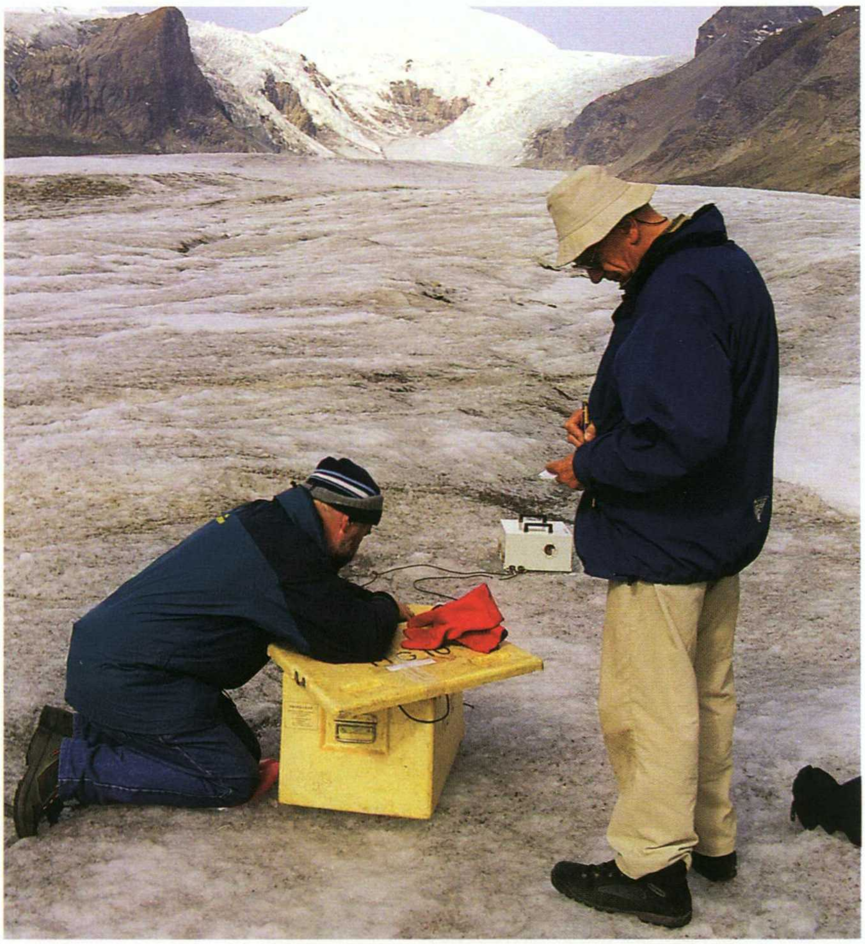
As I said, since the inception of the science, seismologists have considered rotational effects on the surface - because various torsional phenomena were observed, for example the rotation of the bases of statues, or even individual elements in tall columns. Seismologists understood that aside from transverse and longitudinal waves, rotational waves also existed. The problem is that according to the classical theory of solid-state mechanics, rotational waves cannot propagate because they are immediately dampened. But if our theory of mechanics takes account of the bonds between particles, which limit their ability to rotate, then can we explain the propagation of rotational waves in theoretical terms. Thus the argument put forward in the 1920s by Gutenberg, one of the most famous seismologists and founders of modern seismology - i.e. that rotational waves cannot exist - was conclusively invalidated. It was invalidated because modern mechanics allows for the existence of bonds between particles or grains which, among other things, react by creating local torques, or in our model anti-symmetric stresses. Researchers have been studying similar problems of classical solid-state mechanics for more than 100 years, positing very complex theories, i.e. micromorphic theories. In this new approach we have taken to the asymmetrical continuum theory, one that can explain the existence of rotational waves in a simple way.

Do rotational waves play a part in causing destruction during earthquakes?

Yes, they are of fundamental significance in causing destruction within the focus of an earthquake, i.e. its source under the earth. Of course there are rotational effects related to the impact of seismic waves on the Earth's surface, but those are more secondary effects. When a seismic wave reaches the surface, and a building standing in the zone has a certain rotational capacity, then it rotates as a result of the occurrence of various torques. For example, I talked about those columns. But getting back to rotational waves, I would like to stress that it is the destruction of the rock structure in an earthquake focus that leads to the generation of such waves. An earthquake occurs due to either shearing stresses, such as along a fault, or compression stresses, meaning pressure. But it turns out that in the case when a solid is squeezed without any external shear fields, shearing stresses do become induced inside it as a result of rotations. And this is the key conclusion - that the release of energy in an earthquake focus is primarily linked to the destruction of material, due to tearing and rotational motions within the rock medium. This causes a release of seismic energy, and consequently damages on the surface. But these rotational waves do also propagate and most likely have an independent impact on certain surface effects.

You are chiefly a theoretical physicist. Do you feel that scientific inquiry has to be of practical application?

Yes, the point of science is ultimately to produce practical applications. That is its chief task, although science cannot be limited by this. We cannot set out to seek applications, since applications very frequently come completely unexpectedly. Science has to be free from such an imperative to yield applications, because nothing new can be discovered or invented under such an imperative. At most, existing applications



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Seismic shocks can also be triggered by the movement of glaciers, especially large ones like the Hans glacier on Spitsbergen

can be refined, although of course that is also important. The objective of scientific inquiry is generally to produce applications, but that objective cannot be a limitation. I have always fought against that. Research projects which presume that their outcome must be of practical application do not lead to true discoveries, although of course they might yield important improvements in existing applications.

Is this an issue of the priorities for scientific funding?

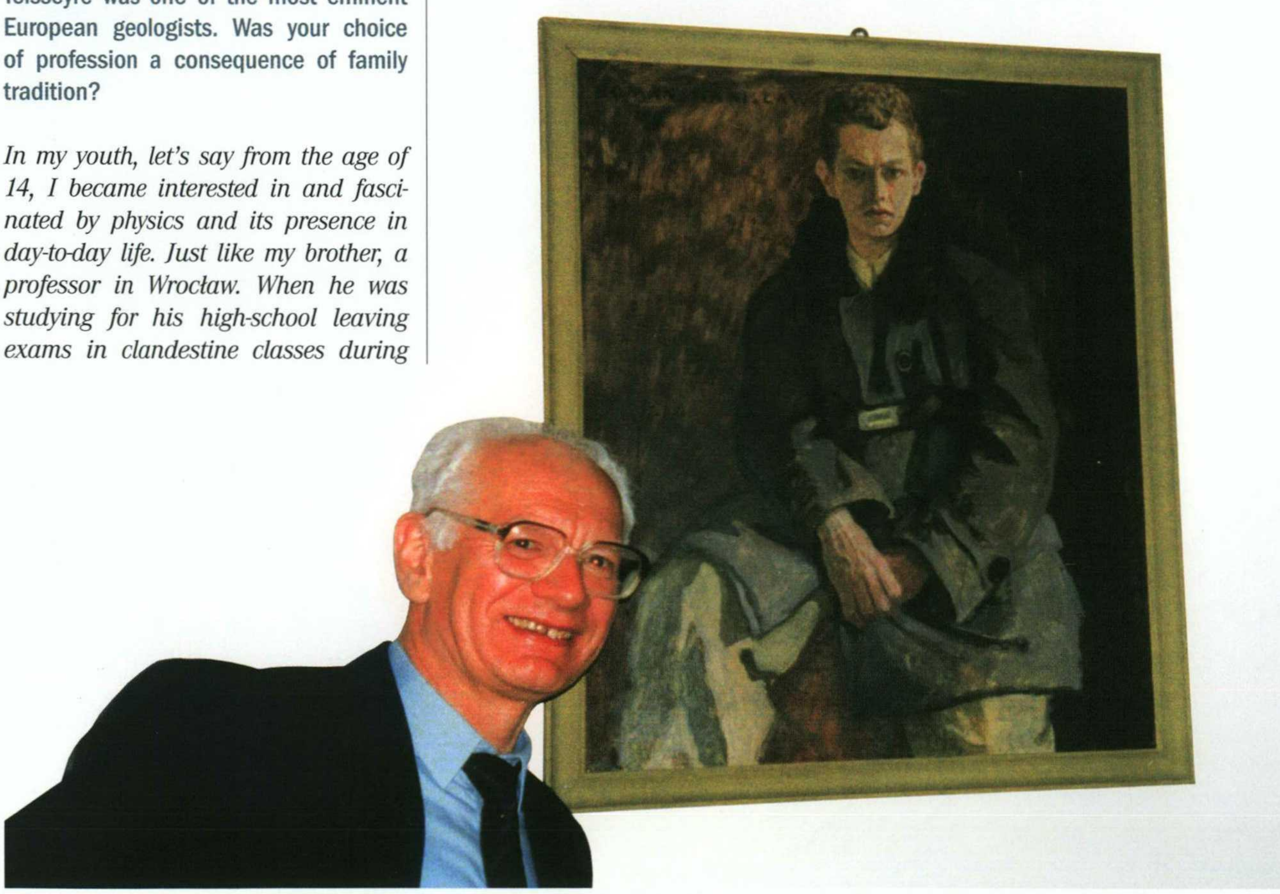
Yes, here lies the mistake of many organizers of scientific research - they fail to appreciate the obvious truth that without funding basic research, we will never make new discoveries that will sooner or later be put to use in practice.

Your grandfather Karol Wawrzyniec de Teisseyre was one of the most eminent European geologists. Was your choice of profession a consequence of family tradition?

In my youth, let's say from the age of 14, I became interested in and fascinated by physics and its presence in day-to-day life. Just like my brother, a professor in Wrocław. When he was studying for his high-school leaving exams in clandestine classes during WWII, I was intrigued by such words as "electron," "atom," and so on. My brother gave me books; I began to read various popular ones. But even read Eddington at that time. After graduating from high school, in Wrocław after the war, I of course chose to study physics. But geology was already a family tradition in view of the achievements of my grandfather Wawrzyniec, and it was then that my uncle, Prof. Henryk Teisseyre, a member of the Academy and founder of the Wrocław school of geology, strongly urged me to take an interest in geophysics. I took part in geophysical research in Lower Silesia in the summer, but I did not allow myself to be "converted" at once. After finishing university, living in Warsaw, I worked with theoretical physics as an assistant to Prof. Infeld. Several years later, however, including as a result of new prospects in geophysical research, I left theoretical physics behind in favor of theoretical geophysics and the application of its methods to practical research, e.g. seismic dangers in the mining industry.

Your family has repeatedly demonstrated its patriotism, and you yourself fought in the Warsaw Uprising. What significance does that have nowadays? Do you believe that scientists have some sort of duty towards their country, such as the duty to do their research here?

Well, I was then a young boy. In fact my father and my brother were greatly involved in the uprising, both heavily injured... What significance does that have nowadays, you ask? I feel it as a strong bond between me and this place, this country. My generation had a chance to learn such a lesson of patriotism... Yes, scientists do of course have a duty towards their country, but that should not restrict foreign trips. Without



Elżbieta Teisseyre

Like his father and brother, the young Roman Teisseyre fought in the Warsaw Uprising. This portrait was painted in Kraków shortly after the collapse of the uprising

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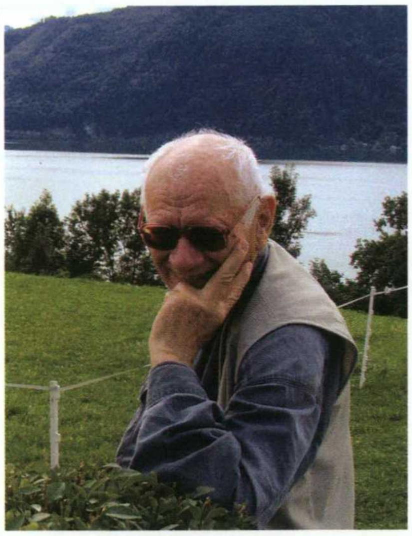

A theoretical physicist by passion, Prof. Teisseyre allowed himself to be "lured" into the field of geophysics - offering an adventure and a chance to put theoretical discoveries into practical application

traveling abroad, without maintaining contacts with world centers, science could not develop well. One has to have broad horizons, because limited domestic horizons may sometimes hamper progress. But I believe that we should always work to ensure that science in Poland develops as best as it can. It always hurts when I see how there is insufficient funding for developing applications based on discoveries made in Polish institutions or laboratories. For example, R&D work on the blue laser went badly - not enough funding was found for working on practical applications. Those are terrible mistakes.

Do you feel that this is just about sources of funding?

It simply seems to me that we have not yet reached a point where we understand that without science - i.e. without fundamental research and then without money to implement its discoveries - we will not see any effects. If discoveries are made, such funding should be found immediately.

Does that mean that cooperation between science and industry is too narrow?

Definitely. A lot of discoveries of various sorts have been made in Poland, but then implemented abroad. That was already true in the postwar years. The understanding was not there.

But now the times are different.

Yes, but the situation is still not improving.

The Institute of Geophysics is an example of a Polish center that has achieved success and world renown. What do you feel has contributed to that?

I have had a bit of influence over how the Institute has developed, and I have always tried to instill a kind of scientific freedom in my colleagues. A talented young researcher should enjoy a large degree of freedom in their work. And the atmosphere should also be quite casual and free. That is very important in science.

But foreign cooperation has also had an impact?

Definitely. Since our Institute's inception we have nurtured various contacts. They were greatly expanded by the International Geophysical Year 1957-58.

You were one of its initiators?

Yes. A Committee for the Geophysical Year was set up, but the organizational work was chiefly handled by our Institute, or at least mostly by people from our Institute. This represented a kind of coming-out into the world. The geophysical expeditions which were then mounted were essentially the first such large-scale research missions taken by Polish scientists outside the country. I think that had a great impact.

What plans do you have for the nearest future? Any new research ideas?

I am now continuing work on the asymmetrical theory of continuous media. This also involves rotational waves, but it reaches beyond seismology. I am working on a book on the topic.

Thank you very much.

Interviewed by:
Andrzej Pieńkowski
Warsaw, May 2007

Prof. Roman Teisseyre was born in Lwów (now Lviv) in 1929. He earned his doctorate at Warsaw University's Institute of Theoretical Physics in 1959, and the title of professor in 1967. He founded the Center for Seismology and then the Center of the Earth's Interior Dynamics at the PAN Institute of Geophysics in Warsaw, which he directed in 1970-72. He was secretary of the Committee for the International Geophysical Year in 1956, then organizer and leader of the Polish geophysical expedition to Vietnam.

He served as a UNESCO expert at the International Institute of Seismology and Earthquake Engineering in Tokyo in 1965-66, as a longstanding member of the Preparatory Commission for the Comprehensive Nuclear-Test-Ban Treaty Organization in Geneva, and as president of the European Seismological Commission in 1976-78. He is editor-in-chief of *Publications of the Institute of Geophysics of the Polish Academy of Sciences* and *Acta Geophysica Polonica* (up to 2005). He introduced into seismology a generalized micromorphic model which allows for the existence of such phenomena as the torsional waves and deformations which accompany earthquakes. He initiated a program of modern seismological monitoring in the mining industry and observations of the shocks caused by glacial movement.

He is the editor and co-author of many international monographs.