«De la nécessité de rêver» Impressions from the Symposium in honour of Rudolf Trümpy held at the ETH Zürich on 2 October 2009: "Alpengeologie im 21. Jahrhundert"

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Introduction

"Of the necessity to dream" is the literal translation of the quotation in the title, which is a heading in one of Rudolf Trümpy's more speculative publications ("Du Pèlerin au Pyrénées")ⁱ. It is clear from the text that "to dream" corresponds to what I like to call "to speculate in a controlled way": based on detailed knowledge of the region under consideration, from one's own field investigations and from published data and descriptions, tempered (and coloured!) by one's accumulated experience of basic geological processes and relationships built up through a lifetime of teaching, research and/or practical application, together with a dynamic working hypothesis which has reached a certain consensus. Based on all these things, the imagination is used to fit the pieces together, to build a picture of an area far larger than a person could possibly investigate in a lifetime - a region, a continent, a mountain range - to a depth in the Earth which will never be accessible, evolving over time spans which, let's face it, are inconceivable. The "dreaming" Ruedi is talking about is not what is often called "geophantasy", or even "geopoetry", which I would distinguish as "uncontrolled speculation". Such speculation is often clearly futile, and one of the attributes of a mature geologist is to be able to keep this apart from real "dreams". What Ruedi is saying is that controlled speculation - "dreaming" - is necessary. As he emphasizes in the paper: "nous sommes obligé de rêver" (my italics). It is an essential part of any geological research, it is not something which can be laid aside, jumped over, not attempted, left to someone else. Without "dreaming", geology (and any other observational science) would not exist.

At the Symposium in Zürich, Ruedi was honoured in ten talks by ex-students and former colleagues, all of them following, to a greater or lesser degree, and in different ways, his admonition to "dream", to engage in controlled speculation. I was asked by the organizers to write some impressions from the wide range of presentations (listed below), most of them starting from some basic contribution made by him at different points in his long and illustrious career, and illustrated with photographs of the man in the field, with the beret and the pipe. He and his many students, Diplomanden and Doktoranden, were field geologists, never happier than being in his and their field areas or on excursions, scrutinising outcrops, interpreting relationships, speculating on correlations, discussing alternatives, and then, later, in the huts, "dreaming" further over glasses of wine. Many speakers touched on this "Golden Age" and regretted its passing, only to present continued work, new investigations, advanced methods, sophisticated tools and new ideas, all building on the solid foundation of Alpine stratigraphy and paleogeography, and its relation to Alpine tectonics, which is Rudolf Trümpy's legacy to Alpine geology in the 21st century.

History, philosophy and "paleo-psychology" (talks 1 and 7, parts of 2, 3 and 10)

Rudolf Trümpy was interested in the history and philosophy of science, particularly in connection with Alpine geology, throughout his career. It was somehow in his bones, and many of his more memorable utterances during lectures and discussions had philosophical undertones. After retirement, these interests expanded and are reflected in a series of articles (see previous article by Stefan Schmid). In a note attached to a separate of the article on Albert Heim, his last publicationⁱⁱ, he wrote "Having almost abandoned science, I indulge in some paleo-psychology". It was clearly very appropriate that two of the symposium talks and parts of several others addressed historical, philosophical and, yes, psychological themes in the connection with Alpine geology. In fact, Andrea Westermann (talk 1) focussed on what Ruedi would have called "paleo-psychology": "Ererbte Gebiete" ("Inherited areas") - the hang geologists have for regarding their mapping areas as their personal property, mentally pinning up signs: "Trespassers will be

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ⁱ Trümpy, R. 1976: "Du Pèlegrin aux Pyrénées". Eclogae Geol. Helv., Vol. 69.

ⁱⁱ Trümpy, R., & A. Westermann 2008: "Albert Heim (1849-1937): Weitblick und Verblendung in der alpentektonischer Forschung". Vierteljahrsschrift der Naturforschenden Gesellschaft Zürich, Vo. 153.

prosecuted". This was particularly common in the 19th century, as she described, when geologists were either rock hounds or great authorities, and it was fascinating to see how the latter defended their territorial rights quite consciously, in writing, and how such rights were passed down from father to son, and mentor to student. Andrea's examples raised many a Schmunzeln, as the audience and the present writer recognized themselves, as in a cartoon. We all thought, well, that was in the past, in the 19th century, probably stretching into the 20th, possibly even quite recently, but not any more! On reflection, however, I realised that it is a basic psychological fact of scientific life – in this age of globalisation it has shifted from the physical field area to the mental and virtual plane: to guard our intellectual property is becoming increasingly difficult, but just as important as it was for Escher, Studer and Heim.

Several talks at the symposium sketched the development of aspects of Alpine geology in the 20th century, particularly the transition from the more fixist geosynclinal concept at the beginning to the more mobile concepts of plate tectonics at the end. Daniel Bernoulli (talk 7) used the title of a publication in 1984 by Rudolf Trümpy: "Des géosynclinaux aux oceans perdus"ⁱⁱⁱ for his broad overview of this historical development, as seen from the Alps. He concentrated particularly on how evidence accumulated which indicated that the Alpine "geosyncline" formed by extensional tectonics and that the Alpine ophiolites could be interpreted as fragments of the floor of "lost oceans". Geosyncline formation by crustal extension and thinning had been in the air since Argand's great synthesis of 1924, but the direct evidence for extension in the Alpine geosyncline only came much later, clearly supported by Rudolf Trümpy's early work (e.g. his doctoral thesis and his famous 1960 synthesis). As Ruedi himself wrote^{iv}, he was at first sceptical of plate tectonics applied to the Alps, basically because he considered the speculations, at first, to be too uncontrolled. With time, however, during the 1970 s, he came to see that it was a well-based working hypothesis and that it provided an enormous impetus for Alpine research as well as way of thinking which clarified numerous Alpine problems. This history, together with the interpretation of the "Steinmann trinity" and Alpine ophiolites, the data from deep seismic profiling and deep sea drilling, and global comparisons, was admirably traced by Daniel, and was touched on in the introductions to several other talks at the Symposium (e.g. talks 2, 3 and 10).

It may seem surprising that I include the talk by Celal Sengor (sorry, Celal, I cannot find the Turkish letters!) in this group. I do it knowing that Celal has a passionate interest in the history of Alpine geology and is a passionate collector of antique geological books, but also because his talk, above all, was an excellent example of my introductory remarks on Ruedi's tenet " the necessity of dreaming". Celal described his early meeting with Ruedi through John Dewey, and his experiences mapping the extremely complicated geology around the Albula Pass in the late 1970 s, with Ruedi's help and guidance ("mit seiner immensen Kenntnis"). He warned of some of the dangers of "dreaming", particularly when one becomes a recognised authority on something and turns controlled speculations into dogmas which do not stand the test of increasing knowledge and understanding. In this case, it was Staub's belief that Alpine tectonics, e.g. on the Albula Pass, was dominated by thrusting, which Celal had to revise in the light of the abundant spectacular fold structures which he observed there. Celal showed in an exemplary manner how he started from understanding the small-scale deformation structures (based on the detailed knowledge of the stratigraphy), put these together into an areal synthesis, retro-deformed them to reconstruct pre-orogenic relationships, interpreted these in terms of the paleotectonics of the sedimentary basin, and then, using analogies to similar relationships all over the world, speculated about the overall development of the rifted margin of the Alpine ocean. At one point I felt that he stepped over the line a little, from controlled to uncontrolled speculation, but then I realised that this had to do with my own limited knowledge of comparative data from other parts of the world, rather than Celal overstepping the mark!

Stratigraphy, palaeontology, sedimentology, paleoclimatology, paleooceanography (talks 4, 5, and 6, parts of 3)

Several talks built on what one may call the basic stratigraphic and sedimentalogical fundament established by Rudolf Trümpy's geological research, based on detailed field mapping and field-based investigations of the fossiliferous formations in the Alps. Karl Föllmi (talk 4) reviewed the latest results of paleo-environmental research in the Helvetic zone, the remains of the 80 kilometer wide carbonate platform which formed on the faulted continental margin, north of the Tethyan oceanic area. He pointed out the obstacles to reconstructing the platform and its paleo-environments in detail, "steep, rainy, slippery and outrageously tectonized", and the essential needs he learnt from Ruedi "thinking in small versus large frames" and "persistence to unravel the stratigraphic history", but also, with "tectonics everywhere, persistence to unravel the tectonic history", as well. Based on this, Karl presented his "dreams", the middle Cretaceous Helvetic shelf as a sensitive indicator of environmental change, induced by global changes in the P and C cycles and sea levels, and changes in local to regional conditions. Helmi Weissert (talk 6) surveyed some aspects of recent paleo-oceanographic research, looking for climate signatures in the middle Cretaceous of the Austroalpine zone, and "dreaming" about the causes of enigmatic things which happened, such as the extreme disturbance of the C cycle, in terms of the opening of equatorial oceanic gateways. Helmi emphasized that the Alps potentially provide the means of studying, not only Mesozoic stratigraphy, sedimentary environments and tectonic aspects of basin formation (the Trümpy school in the 20th century), but also, and building on that, oceanographic and

ⁱⁱⁱ Translated: "From geosynclines to lost oceans". Bull. Soc. Géol. France (7), 26, 201–206.

^{iv} Trümpy, R. 2001: "Why plate tectonics was not invented in the Alps". International Journal of Earth Sciences, Vol. 90.

climatological aspects of the associated water and air masses (temperature variations, changes in ocean currents, CO_2 - circulation) and the influence of the interplay between tectonics and climate on the sediment archive during the Tethyan (pre-orogenic) phase in the Alps – looking towards the 21st century.

Of a different character was the talk by Heinz Furrer (talk 5) - "The fish in the mountain" - with its superb photographs of the fish fossils and other marine organisms recovered from the Prosanto formation (Middle Trias) in the Upper Austroalpine cover sediments lying on the crystalline basement of the Silvretta nappe in the Ducan area. The fish were "caught" in this high-alpine area by teams of volunteers during 1-2 week field campaigns every summer, by painstaking splitting and documentation of the flaggy fossiliferous horizons, centimetre for centimetre. The complete fish with all their scales, fins and heads were then exposed in the laboratory by fine preparation work over periods of 2-4 weeks. Heinz also showed some results from the precise dating of zircon grains in ash horizons in the Prosanto formation, giving the ages to the nearest 10,000 years. Altogether a spectacular locality, and spectacular results which bode well for continued progress as the 21st century proceeds!

All three talks in this group have certain things in common. They were all based, to a large degree, on the broad platform of detailed geological maps and detailed stratigraphic profiles produced by Rudolf Trümpy and his Diplomanden and Doktoranden, not working alone in the Alps, of course, but in Eastern Switzerland almost. The talks all pointed to the future, which is what the title of the Symposium implies. And the research reported in each case made use of what I call "orogenic accessibility" - the fact that the mountain building, although it folded, faulted, transformed and disturbed the original flat-lying and slowly accumulating layers, sometimes almost out of recognition, also uplifted and eroded the same, providing the possibility of studying geological objects and relationships which would otherwise be out-of-reach and hidden for ever. A world without orogeny would be a world without interest, for both stratigraphers and structural geologists, and the geophysists who would rule that world would be without the means of validation. Only the oceanographers would be happy. This prompts me to point to one aspect of the geology of the Alps which is likely to survive the 21st century, and which was not specifically mentioned in the Symposium. Because of "orogenic accessibility", and supported by the superb Swiss communications system, from international airports to marked footpaths, and by the long history of detailed geological research and detailed topographic surveying, not to mention the stable society, good climate, good exposure in the higher regions and good accommodation almost anywhere - because of all this, the Alps will remain hugely attractive as a natural geological laboratory. I am not thinking here only of geo-tourism in all its forms, which will certainly still continue (Geopark Sardona - one of Ruedi's pet projects!). I am thinking more of university-level teaching and industry-related training, which aims at developing this ability to "dream", to speculate in a controlled way, which is the key to success, not only in academia but also in applied geoscience. Without such ability, for instance, the oil industry would still be in its infancy, modelling and prediction would be unknown concepts, exploration would be lamed. The field workshops in the Alps organised by many oil companies every year for their geoscientists are not considered as diversions, they are of vital importance for exploration and reservoir modelling. How can one "dream" of a faulted continent margin on a work station, without having walked around inside one, looking directly at its internal structure and sedimentary makeup, exposed in 3D by the Alpine orogeny and subsequent erosion, and easily sampled? These were some of the thoughts on the Symposium theme provoked by this group of talks.

Structural geology, geophysics, tectonics and "paleogeomorphology" (2, 8 and 10, parts of 3 and 7)

The "outrageous tectonics" and the uplift and erosion which created the "orogenic accessibility" necessary for studying the inside of sedimentary basins and oceans in the Alps was the subject of three further presentations at the Symposium. A well-known and, for some, slightly irritating saying of Ruedi's was, "You can explain an orogeny without fossils - on condition there aren't any!"^v. Fortunately, at least two of his Doktoranden ignored the taunt and went on to research orogenic processes in the Alps in all their aspects, based, of course, on the Trümpy legacy, but expanded to include all aspects of geology - experimental rock deformation, petrofabrics, structural geology, metamorphic petrology and all the rest. Ruedi had an intuitive grasp of Alpine tectonics, and dreamt many "dreams"; Stephan Schmid (talk 2) and Adrian Pfiffner (talk 8) have used field-based structural and geophysical data to create a documented and argumented tectonic model of the Alpine orogen "from the Earth's surface down to the mantle", in cooperation with many other scientists from different disciplines vi, as acknowledged in both of the presentations. Stefan's talk dealt with more large-scale features of the Alpine chain, including the deep structure based on deep seismic profiling and teleseismic mantle tomography. He painted a complex picture of the Alpine orogen, emphasizing the interaction of irregularly shaped microplates, with different relative motions at different times - "the Alps are extremely non-cylindrical, a composite formed by 2 orogenies and the closing of 3 oceans" and "there are dramatic strike changes at a crustal and lithospheric level". He showed that the complications could be unravelled - that his "dreams" and speculations were tightly controlled by timing, geometry and material properties - and that, however irregular, there is no reason to use the word "chaos" (which would im-

^v This is the version I remember; a similar version was given by Francis Hirsch, one of Ruedi's earliest students at Zürich, who quotes it in a letter containing many personal memories read aloud at the Festessen to Ruedi's memory at Filzbach, the day after the Symposium.

^{vi} Much of this work was carried out in working groups of the Swiss National Research Programme, NFP 20, as exhaustively documented in the atlas "Deep Structure of the Swiss Alps" (Birkhäuser, Basel etc., 1997).

ply uncontrolled speculation or "geophantasy"). New insights into the Alpine orogeny, relevant for orogeny worldwide and based on interdisciplinary teamwork, will clearly continue to be gained as the 21st century proceeds.

Adrian's talk was equally enlightening, although differently oriented, focussing exclusively on the structure of the Helvetic zone, Rudolf Trümpy's geological home. With a stratigraphy known in such great detail from Ruedi's and his students' work, the Helvetic zone has become a fantastic playground for tectonicians using the specialized tools of structural geology - structural analysis, retro-deformation, balancing of crosssections, mechanical stratigraphy, etc. At this scale also, Adrian illustrated with beautiful cross-sections how "structural cylindricism" is of little use, even from one valley side to the other, and how a good knowledge of the rules of fold-and-thrust-belt tectonics built up in other areas (often oil-rich and therefore extensively drilled and seismically profiled) can allow more reliable 3D reconstructions to be made. In orogenic belts, the presence of fossils (stratigraphy) is a great help, but it is by no means the end of the line.

The final talk in the Symposium was by a new colleague of Rudolf Trümpy, whom, he regretted, he had not had time to get to know. Nevertheless, Sean Willett (talk 10) started with an enigmatic quotation from Ruedi's early but classical synthesisvii, that the Alps "were not more than a hilly tract of country by the beginning of the Pliocene". "How on earth did he know this?" Sean asked. He used this question as the starting point for a fascinating talk about the complicated interaction between tectonics, erosion and climate around growing mountain chains, and modern methods of obtaining more information to quantify changes in elevation, relief and erosion at intervals during the morphological growth of the chain, such as fission track and cosmogenic dating. Combining the fragmentary evidence from many different lines of argument, Sean came to the conclusion that the maximum height (and width) of the Alps as a geomorphological feature was reached at the end of the Miocene, and that the Pliocene-Pleistocene Alps were lower but more rugged than they were in the Miocene. A nice example of how a poorly controlled speculation (Ruedi's 1960 geological intuition) stimulates further research which, with new data and new insights from many different disciplines, leads to greater understanding and better controlled conclusions!

"Moral und Nutzanwendung?" (talk 9)

"Moral and practical application?" – with these words Rudolf Trümpy used to like to introduce the conclusions of his talks and lectures. "What do the observations and interpretations I have just presented lead on to?" He was an expert at identifying the broader significance of even the most scrappy of outcrops. His students learnt this scientific attitude – the necessity of "dreaming" – and carried it out into the world of practical geology, where most of them made successful careers. It seems appropriate, therefore, to end this brief survey of the Symposium with the talk by Henry Näf (talk 9), who carried his grounding in the stratigraphy of the Lower Austroalpine Trias into the practical world of applied tectonics and geophysics, particularly of the northern foreland of the Alps. Henry reported on current exploration along the Alpine front related to the development of deep geothermal resources as a source of energy, on the example of the proposed deep drilling in the city of St. Gallen. Specifically, the project concerns the siting of the deep exploration borehole, proposed depth ca. 5 kilometres, and Henry showed graphically how the final decision will be based on a synthesis of a wide range of data on fault zones, mineral and thermal water occurrences, temperature/depth measurements, compilations of previous deep drill-holes and reflection seismic lines over a wide area, earthquake activity and its relation to tectonics, drilling technology, land use and planning ... and, last but not least, the stratigraphy of the Alpine foreland basin and its implications for the reconstruction and modelling of the subsurface geology at the proposed drill site.

Concluding remarks

"Alpine geology in the 21st century"? Who knows what new techniques, new ideas, new initiatives will bring in the rest of this century? Who can tell whether the many "dreams" presented in this Symposium will be confirmed or abandoned? What we can say for sure is only that the Alps will continue to be one of the most important natural laboratories in the world for teaching and learning about the Earth and how it works. It will continue to fulfil this role partly because of the solid foundations laid by Rudolf Trümpy and his students, which are not likely to be superceded.

PRESENTATIONS AT THE SYMPOSIUM (WITH SPEAKERS)

- Ererbte Gebiete. Die Glarner Alpen, Wissensvalidierung und die genealogische Organisation der schweizerischen Geognosie im 19. Jahrhundert (Andrea Westermann).
- (2) Anatomy and growth of a mountain belt: A look at the Alps from the Earth's surface down to the mantle (Stefan M. Schmid and Eduard Kissling).
- (3) Eine überschobene Kontinentalböschung im Albulapassgebiet, Graubünden: synthetischer oder antithetischer Kontinentalrand vom atlantischen Typus? (Celal Sengör).
- (4) Paleoenvironmental research in the Helvetic thrust-and-fold belt (Karl Föllmi).
- (5) Der Fisch im Berg. Paläontologie und Stratigraphie in der ostalpinen Trias Graubündens (Heinz Furrer).
- (6) Neptuns Spuren die Paläozeanographie und ihre Bedeutung f
 ür die Alpengeologie (Helmi Weissert).
- (7) Alpengeologie im 20. Jahrhundert: Von der Geosynklinale zu den verlorenen Ozeanen (Daniel Bernoulli).
- (8) Die helvetischen Decken: Bau, Entwicklung und Paläogeographie (Adrian Pfiffner).
- (9) Der Ostschweizer Alpenrand in Licht zweier Tiefengeothermie-Projekte (Henry Näf).
- (10) Late stage erosional history of the Alps: What happened at the end of orogeny? (Sean Willet).

Published Online first November 30, 2009

^{vii} Trümpy, R. 1960: "Paleotectonic evolution of the Central and Western Alps", Bulletin of the Geological Society of America, Vol. 71.