In the footsteps of Emile Argand : Rudolf Staub's Bau der Alpen (1924) and Bewegungsmechanismus der Erde (1928)

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In the footsteps of Emile Argand: Rudolf Staub's Bau der Alpen (1924) and Bewegungsmechanismus der Erde (1928)

By Rudolf Trümpy[1])

ABSTRACT

Rudolf Staub's masterpiece, the "Bau der Alpen" (1924), follows Emile Argand as far as the general method and the Western Alps are concerned, but furnishes an original synthesis for the Eastern Alps. The book is accompanied by a beautiful set of cross-sections through the entire chain. It is the very embodiment of the "cylindristic" method of nappe correlation, a necessary step in the understanding of Alpine structure. The "Bewegungsmechanismus" of 1928 is a curious and little-known attempt at a definitely mobilistic, intuitive analysis of global mountain structures.

Staub's method of thinking was criticized by his contemporaries, including Emile Argand. He was a great geologist, but a visionary rather than an "objective" scientist.

ZUSAMMENFASSUNG

Rudolf Staub (1890–1961) war einer der letzten der Geologen-Generation, welche das grosse Abenteuer der Erkenntnis des alpinen Deckenbaues miterlebte und mitgestaltete. Er war ein ausgezeichneter Feldgeologe, mit einem sicheren Auge für tektonische Zusammenhänge und einer aufrichtigen Liebe zur Natur und Bevölkerung des Gebirges.

Staub's Meisterwerk ist der «Bau der Alpen» von 1924. In bezug auf die Methodik und die Westalpen folgt er Emile Argand. Die Synthese der Ostalpen ist durchaus originell, und er hat viele wichtige Strukturen der ostalpinen Decken richtig erkannt. Sein einzigartiger Versuch, den Bau der gesamten Alpen durch Quer- und Längsprofile darzustellen, ist kaum je wiederholt worden. Die Decken werden auf Grund der Geometrie, der Entwicklung der mesozoischen und alttertiären Schichtreihen, aber auch des Charakters der Grundgebirgs-Komplexe und der Art der alpinen Metamorphose im Streichen korreliert. Der Bewegungssinn wird konsequent vom adriatischen Sporn Afrikas aus gegen Europa angenommen, das Alter der Deckenbewegungen fast ausschliesslich auf das Tertiär beschränkt. Das Ergebnis ist die Quintessenz des «Zylindrismus», eines notwendigen Schrittes in der Deutung der alpinen Strukturen.

Staub's «Bewegungsmechanismus der Erde» (1928) ist ein interessanter Ansatz zu einer intuitiven, mobilistischen Gesamtschau der irdischen Gebirge. Sie basiert auf dem sehr einfachen «Modell» eines Kräftepaares Polflucht-Poldrift.

Staub's Beziehungen zu seinen Zeitgenossen, auch zu Emile Argand, waren einerseits freundschaftlich, anderseits nicht ungetrübt. Seine Denkmethode musste zu Kritik herausfordern. Er war ein grosser Geologe, aber ein Visionär – vielleicht ein Künstler – eher als ein «objektiver» Wissenschafter.

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Introduction

Rudolf Staub (1890–1961) came of Glarus stock. He went to school at Trogen (Appenzell A.R.) and studied petrography in Zürich. His teacher, Ulrich Grubenmann, suggested "the talcschists of the Bernina group" as his thesis subject. In fact, there are hardly any talcschists in the Bernina, but little was known about the geology of these mountains at the time. After highly productive years as an independent scientist (Privat-Dozent), Staub became professor in Zürich in 1928, succeeding Hans Schardt. He retired in 1956 and died in his mountain home, in the marvellous Fex valley of the Upper Engadine (Obituary: see NABHOLZ in ARQUINT et al. 1961).

When I knew Rudolf Staub, from 1940 onwards, he was an impressive man, sturdily built, with a florid face, a strong nose and great, bristling eyebrows. Most conspicuous items of his field attire were a red handkerchief around his neck and a wide-brimmed hat. In his youth, he was an expert mountain climber and made many difficult ascents, often in company of the legendary mountain guide Christian Klucker. He obviously enjoyed life (in the german-speaking part of Switzerland, this is considered as a serious moral defect).

Rudolf Staub's work is centered on the Alps and particularly on Graubünden, where the axial flexure between the Central and the Eastern Alps exposes almost the entire bundle of alpine nappes. Others had recognized the challenge of Graubünden geology, but Staub made the most of it, sometimes in cooperation and often in competition with colleagues like Hans-Peter Cornelius from Vienna, Paul Arbenz and later Joos Cadisch from Berne. Staub had private means and could afford a motor-car even in the mid-twenties, which gave him an advantage of mobility and facilitated comparisons with distant parts of the chain.

Staub was above all an outstanding field geologist, with an excellent eye for structural relations and a working knowledge of petrology. His 1:50,000 maps, especially Val Bregaglia (1921b) and Avers (1926b) are masterpieces of alpine field-work in complex and difficult areas. The great Bernina sheet (1946) is more heterogeneous: some parts are quite excellent, while others were apparently drawn after incomplete notes and sketches[2]).

Between 1916 and 1922, Staub wrote a number of important papers, based on his observations in Graubünden: on the tectonics of southeastern Switzerland, 1916; on the distribution of facies, 1917 (following and almost leading ad absurdum Argand's theory of embryonal tectonics); on the W-E sections, 1919; on metamorphism, 1920 and on the distribution of ophiolites, 1921a. Finally, between 1924 and 1926, he produced his magnum opus, "Der Bau der Alpen".

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[2]) It is great fun to walk around in the latter areas, trying to find out just why Staub drew what and where. There is always some reason behind it. We should also remember that mapping on Italian territory had to be done surreptitiously, during the fascist episode.

The "Bau der Alpen"

The backbone of this work consists of a tectonic map (1924a) and 25 cross-sections (1926a). This attempt at serial profiles through the entire chain has never been repeated. Staub's sections are beautiful – he had the Platonic concept according to which beauty was a criterium for truth – and absolutely plausible: they can easily be modified to fit "modern" theories and seismic data. Their construction rests on Staub's personal and often pertinent view of "tectonic style", and less than Argand's 1911 profiles on geometrical construction.

The book itself (1924) does not make easy reading. The style is rather turgid – a defect to which the german language lends itself easily. Staub's Austrian friend and rival, Leopold KOBER (e.g. 1923) was even worse in this respect. Furthermore, the author is addicted to beautiful place-names, often difficult to find on maps and baffling to the lowland reader (this tendency will become even more pronounced in Staub's later works). These names meant very much to Staub: mountains he had seen and climbed, valleys where he had talked and drank with the local people.

The chapters on the Western Alps reproduce Argand's views. The treatment of the Eastern Alps, on the contrary, is quite original. We shall choose a few examples in order to illustrate Staub's philosophy of nappe correlation.

In 1924, Staub is very positive in correlating the Dentblanche nappe of the Pennine Alps, the highest Penninic nappe according to Argand, with the Margna nappe of Graubünden (p. 30). He invokes the character of the basement rocks, the position in the structural edifice and the facies of the Mesozoic cover rocks, and he asserts that the latter are "beyond any doubt arch-penninic" (urpenninisch – ohne Zweifel erwiesen). In 1937, he will insist, with the same absolute assurance, on the Lower Austroalpine character of the Dentblanche. The latter view has generally prevailed; but some of us are wondering whether Staub's original correlation was not better justified. Basement rocks, structural style and type of Alpine metamorphism of the Dentblanche nappe are quite different from those of the Err and Bernina nappes. Dentblanche and Margna may be analogous (certainly not homologous), and the two can be grouped under the noncommittal term of "Ultrapenninic".

Like all swiss geologists of the time, Staub was convinced that the Prealpine nappes were of Lower Austroalpine origin. Errare humanum est, perseverare diabolicum: it is difficult to understand how this correlation could persist into the fifties of this century, although HAUG (1925) had clearly pointed out the Briançonnais connection. Poor stratigraphy, notably the misinterpretation of the section on Piz-Nair, above St. Moritz, by STAUB (1948) and CORNELIUS (1935), corrected only in 1944 by Franz ROESLI, may be one reason. Another one was the idea of primary, "geosynclinal" metamorphism – Swiss geologists could not conceive how the non-metamorphic Prealpine nappes were derived from an area now affected by Alpine metamorphism. Provincialism, so strong in the thirties and forties, may also have played its regrettable part. The definite proof for the Briançonnais derivation was only furnished by ELLENBERGER, in 1952.

The "Swiss", Lower Austroalpine solution led to endless difficulties and squabbles, notably in central and northern Graubünden. Staub advanced a fairly elegant tectonic solution in order to explain how "Austroalpine" slices came to lie below, within and

above the Penninic, ophiolite-bearing parts of the Arosa Zone. He regards the Arosa Zone (in the widest sense) as a "wildes Haufwerk von Schuppen mit den allerverschiedensten faciellen und tektonischen Elementen[3]) (p. 95) – in other terms, a mélange. In fact, the Briançonnais-derived Prealpine elements, which include Tertiary formations, lie everywhere below the true Arosa mélange and are not involved in it. But there is indeed a tectonic mixture apparently formed during the Cretaceous (eo-alpine) deformations, of oceanic, ophiolite-bearing "matrix" with slivers, of all sizes, of Lower Austroalpine (Err- and Bernina-derived) and possibly also Ultrapenninic (Margna-derived) sediments and sialic basement rocks. Staub was also right in observing (p. 136) that in the Lower Engadine window, the "Prealpine" Cretaceous formations of the Falknis (Tasna) nappe were in close relation with "Lower Austroalpine" Variscan granitoids (cf. GRUNER 1981).

The most interesting and original chapters deal with the Austroalpine nappes of the Eastern Alps. Staub remained true to his cylindrist assumptions and tried to follow the three major basement nappes of Graubünden – Campo, Silvretta and Oetztal – all the way to the Pannonian plain. This obliged him to draw rather dubious boundaries right through coherent complexes of basement rocks. But he understood some very important relationships. Thus, he recognized the position of the Brenner-Tribulaun Mesozoics as cover of the Oetztal basement nappe (p. 169 ff.); TERMIER (1905) had interpreted them as a sort of extravasion of the Penninic Tauern window rocks.

Staub was the first to see the importance of an "Ultra-Austroalpine" or "Dinaric" thrust-sheet, preserved in the Nösslach outlier to the W of the Tauern window, in the Stangalm nappe and the Graz Paleozoics (p. 189).[4]) This provided him with an easy opportunity to deride his Graz enemies, Heritsch and Schwinner[5]), in whose Styrian home ground it took "a zoologist" (HOLDHAUS 1921) to discover the Mesozoic fossils below the Stangalm klippe. Staub's parallelization of the Innsbruck and Landeck quartz phyllites is not accepted by present-day Austroalpine geologists, but may merit reconsideration. For the facies distribution in Late Triassic time, his figure 57 presents a very "modern" concept.

In other respects, Staub was rather conservative. He was not fault-conscious[6]); he failed to recognize the importance of the Insubric accidents[7]) (of which Argand had taken account), and he did not see the Engadine Line, right in front of his Fex valley.

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[3]) A savage jumble of slices, composed of the most diverse facies and tectonic elements.

[4]) Staub kept great interest in the significance of these klippen and questioned me about them, in my final exam of 1947.

[5]) Staub and Schwinner shared a feeling of real enmity. Schwinner finally disqualified himself by an ignoble pamphlet (1940), in which he proved that "the Swiss" (meaning Staub) had wrongly interpreted the Eastern Alps by following "a frenchman" (Termier) and "a half-jew" (Suess).

[6]) The Oxford dictionary gives for "fault": 3, error; 4, place where there is a break in the continuity of layers of rock. Both definitions apply.

[7]) In the thirties, Staub did indeed acknowledge the importance of the Tonale Line. He even claimed that he could distinguish, among his beloved Valtellina wines, those which came from grapes grown north or south of the fault (information from Augusto Gansser). There may be a geological reason – the gneisses north of the line contain marble layers, which are lacking to the south – but there is a more obvious topographic reason: the vineyards to the north of the line occupy the higher slopes, those to the south the lower ones.

The "Bau der Alpen" is the very embodiment of the much-maligned "cylindrism". Nappes were followed from one end of the chain to the other: they had an individuality of their own, with their characteristic basement rocks, Mesozoic cover, structural style and metamorphic grade. They were even credited with their own will (Monte Rosa penetrated into Bernard, Oetztal crushed Silvretta). This was a necessary step in our understanding of the chain, just as the dismantling of cylindrism, initiated by Ellenberger and others around 1950, was necessary.

Although Staub acknowledged the importance of backthrusting – like Argand, he recognized the underthrusting of the "Dinarides", i.e. the Southern Alps, below the main body of nappes – he stressed the prevalence of south-to-north directed movements. He had a tendency to minimize the effects of Cretaceous deformation, which he believed to be restricted to the highest, Juvavic sheets of the Northern Calcareous Alps.

Staub's views on alpine metamorphism (p. 240 ff.) are highly interesting. He stated that the regional, heat-controlled metamorphism was essentially post-tectonic, and that it was preceded by a pressure-dominated "dynamic" metamorphism. Needless to say that the considered both to be of Tertiary age. Staub does not always seem to have drawn the consequences of this insight. In addition, he invoked a regional Mesozoic, "geosynclinal" metamorphism – a concept which has led, as already mentioned, to some errors, although traces of oceanic metamorphism may indeed be detected locally.

Staub's conclusions are remarkably clear and far-sighted. His characterizations of the Helvetic zone as deformed European foreland, of the Penninic zone as an oceanic domain and of the Southern Alps as African "Rückland" is still valid. On p. 233, he says: "die ostalpinen Decken sind Splitter des Rücklandes". It would not be far-fetched to translate "Splitter" by "flake" (Oxburgh 1972).

Staub insists on the unity of Eastern and Western Alps, some of his arguments – such as the supposed continuation eastward of the External Massifs, or the correlation of deformation phases – being rather questionable. He asserts the absolute dominance of south-to-north movements, going as far as to consider the Apennines, Dinarides, Hellenides and Taurides as "mere superficial backfolds". The Alps, and all Mediterranean mountain chains, were created by the advance of Africa. He concludes (p. 257):

"Europa und Afrika wanderten gemeinsam nach Norden. Europa flieht vor Afrika seit den Tagen des Perms, aber der gewaltige Koloss holt das kleine Europa schliesslich im mittleren Tertiär ein und treibt die Böden des einstigen grossen Ozeans zwischen Europa und Afrika als gewaltiges Gebirge über dasselbe hinaus"[8]).

Using very simple and approximate paleoclimatic reasoning, Staub evaluated the northward drift of Africa since the Permian at 50° latitude (5500 km), the crustal shortening in the Alps at 1000 to 1500 km.

By the mid-twenties, Argand and Staub had conceived a model of the Alps which came very close to the present views. True, they assumed, with Wegener (1915), that

[8]) Europe and Africa wandered north in common. Europe flees ahead of Africa since the days of the Permian, but in the middle Tertiary, the gigantic colossus finally overtakes little Europe and drives the floors of the former great ocean between Africa and Europa over the latter, in the form of a tremendous mountain chain (Staub's prose defies translation).

only the crust was moving on the "sima". But for the Alps, they were even not very wrong, as alpine structures involve mainly continental and oceanic crust, in the majority of instances only upper crust. Of course, lithospheric slabs of upper mantle and lower crust must have been subducted somewhere, but not necessarily beneath the chain itself.

The "Bewegungsmechanismus"

In 1928, STAUB attempted a synthesis of the tectonic evolution of the entire Earth. This book, the "Bewegungsmechanismus der Erde", was apparently little read and is seldom quoted; it appeared at a time when the fixist, anti-Wegenerian backlash was becoming to be felt.

Staub's concept (or, in fashionable terms, model) was extremely simple. He assumed two mobile supercontinents, Laurasia and Gondwana, and a stable mass, the Pacific. All mountain belts are due to the convergent movement of Gondwana and Laurasia, either in frontal collision with each other or in lateral, oblique collision with the Pacific block. This implies that all chains really belong to one system, with the Alps (and Graubünden in particular) in the center of the universe. Such an arrangement implies that the circum-Pacific belt be divided into four segments: the northern branch of the Mediterranean-Himalayan chains is supposed to run into western North America and eastern Asia, the southern one into the Andes and the southwestern Pacific. Unlike Wegener and Argand, Staub does not accept the separation of the two hemispheres by an Atlantic opening. Instead of this, he draws some (mildly expressed) pretty fanciful trans-Atlantic connections of fold-belts, based only on then available bathymetric maps, between the Antilles and Gibraltar. He is also obliged to minimize the significance of the Antillean and Moluccan arcs.

The process of Gondwana-Laurasia collision has acted repeatedly: "Jede Gebirgsbildung trägt so in sich ganz unfehlbar den Keim zu einer nächsten Orogenese, indem sie eine neue Geosynklinale schafft"[9]) (p. 213). "Geosynclines" thus originate on the site of a preceding suture, or slighly outside of it. This is a premonition of the so-called "Wilson cycle".

Staub saw the main driving mechanism in Wegener's Polflucht, the migration of continental slabs toward the equator, triggered essentially by centrifugal forces. Alpine-type mountain ranges thus are formed near the equator, or somewhat away from it in those cases where the movement of one block is faster than that of the other, as Africa's against Eurasia's in the Mediterranean segment. Once the crustal thickening by collision has been achieved, a deep undercurrent will again draw the collided blocks apart, by Poldrift. The Polflucht-Poldrift couple provides a sort of perpetuum mobile[10]). Staub attaches only secondary importance to the tide-controlled longitudinal movement of continents, Wegener's Westdrift.

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[9]) Each act of mountain-building thus quite inevitably bears in itself the germ of a succeeding orogenesis, by creating a new geosyncline.

[10]) This was pointed out in the fall of 1942, by a remarkably modest second-year student, in a seminar talk on "the causes of mountain-building".

One is inevitably led to compare STAUB's Bewegungsmechanismus with ARGAND's "Tectonique de l'Asie" (1924b). Both books have the same origin-sound field work in the Alps and the application of Wegener's ideas. Staub's work definitely ranks second. There are far less concrete geological data, and the evidence is sometimes stretched or compressed beyond recognition to fit on the Procrustes' bed of the hypothesis. Staub's theoretical grasp of geophysics (and of physics in general) was also rather superficial. Still, the Bewegungsmechanismus is an interesting interpretation of the tectonics of the Earth.

Among STAUB's later work, a mention should at least be made of the delightful Alpine Morphology (1934), his most inspiring publication. The attempt at using Alpine erosion products in the Molasse Basin and in the Quaternary gravels for the reconstruction of kinematics follows very modern trends.

Staub and Argand

Today, we are commemorating the 50th anniverary of Argand's death, which coincides with the 100th anniversary of Staub's birth. So we need to discuss the personal relation between these two great alpine geologists. It is common knowledge that they were far from simple.

In his writing, his teaching and in private conversation, Staub always professed his great respect for Argand and acknowledged his indebtedness to Argand's ideas. This admiration was not quite symmetrical, although Argand as well appreciated the "Bau der Alpen". Staub had worked at Neuchâtel from november 1922 to spring 1923, and in the following summer the two geologists went on a long field trip in Graubünden. During their ensuing misunderstandings, Staub liked to recall some of their passwords from this excursion: viva la Grischa, venga för l'artiglieria, sclupetoir and scimingott[11]).

Jean-Paul Schaer has enabled me to study the correspondence between Argand, Staub and Albert Heim (called in as mediator) in 1924. I thank him for this opportunity, but at the same time I almost wish not to have read these letters. They make hero-worship even more difficult than it was. Both men do not come out of this confrontation unscathed. Argand shows a primadonna stance and attaches undue importance to petty questions of priority, such as the publication dates of his four-page note "Des Alpes et de l'Afrique" (June 1924) and of the text of Staub's work (September 1924). Staub was submissive and almost grovelling. He was deeply unhappy about the quarrel, and probably also worried about his career[12]. From 1919 onwards, there had been several frictions, the attacks always coming from Argand and sometimes containing a grain of justification.

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[11]) Romanic for: long live Graubünden; bring the canons forward; a coarse term related to bodily functions; a term of unknown meaning (informations by Gian-Andri Niggli, teacher in Sils/Segl, and by Conrad Meuli, mountain guide in the Fex valley).

[12]) Asked to give his advice in 1928, when Schardt went into retirement, Argand denigrated Staub's work (rather unfairly) and extolled that of his friend Paul Arbenz, who was indeed probably the best and certainly the most humane of the swiss geologists at that time (letter to the president of the ETH, communicated by J.-P. Schaer). The chair at the ETH was first offered to Arbenz, but he preferred to stay in Berne.

On october 28th of 1924, Argand wrote to Leopold Kober on the "Bau der Alpen"; "Sur bien des points, cette synthèse doit approcher du définitif. Quant à sa carte tectonique des Alpes, c'est un monument merveilleux de clarté et de transparence. ... Mes deux travaux, et principalement mon 'Asie', définissent le rôle somme tout très mesuré que j'attribue à ces grands charriages bicontinentaux. Ce rôle est en somme modeste si l'on se place, comme je l'ai fait, à l'échelle planétaire. Mais il paraît évidemment de premier ordre quand on part, comme l'a fait R. Staub, de l'échelle des Alpes"[13]).

This neatly defines the difference – and the hierarchical order – between the two: Argand was a truly global geologist, Staub an alpine geologist who tried his hand at global tectonics.

On november 25th, 1924, their controversy being, at least monentarily, patched over, Staub wrote to Argand: "Notre union cela fait la force de nos idées, et il n'y a rien de plus beau que l'amitié entre deux hommes qui jouent le même jeu, jeu d'artistes qui voient la grande vérité par l'intuition, par le feu sacré de l'esprit qui les emporte au dessus de tout"[14]).

This is a truly revealing statement, not so much on Emile Argand as on Rudolf Staub himself. Alpine geology is a game, a game of artists, played by intuition. A game has rules, but no laws. This is what makes Staub's contributions so difficult to evaluate; results achieved by intuition are often valid, but very hard to reproduce and to falsify. At heart, Staub may have been less an exact scientist (sensu popperiano) that a romantic poet – and this remark is by no means to be considered as a disparaging judgment. He literally **saw** the beauty of mountains and of their structure, without taking the detour of logical reasoning.

Staub was probably underrated by his contemporaries and by posterity. He had the misfortune to run against two greater scientists in his two fields, against Emile Argand as an alpine geologist and against Paul Niggli as a teacher at the ETH.

To us, former students of Rudolf Staub, the exciting and inspired lessons he gave us from some mountain top are unforgettable, in spite of the misgivings we may have had about his scientific methods. In some way or another, we are all marked by his influence.

Acknowledgments

I have learnt much about Staub from older students of his, like Augusto Gansser, Heinrich Jäckli and Johannes Neher, who knew him during his heyday. They are not responsible for the critical comments I was obliged to make on some of the works of a teacher and, for a few years, senior colleague whom I liked and admired.

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[13]) On many points, this synthesis must come close to a definitive solution. As to his tectonic map of the Alps, it is a marvellous monument in its clarity and transparence. ... My two works, and especially my "Asie", define the very limited role which I assign, after all, to these great bicontinental thrusts. Their part is finally modest if one puts oneself, as I have done, on a planetary scale. But it appears of course to be of the first order if one departs from the scale of the Alps, as R. Staub has done.

[14]) It is our union which gives strength to our ideas, and nothing is more beautiful than the friendship between two men who are playing the same game, a game of artists who see the great truth by intuition, by the sacred fire of the spirit which carries them on beyond everything.

1917 at "Lochseite" (Glarus): Four men singing the glory of the glaronese nappes. From left to right: Emile Argand (Neuchâtel), Alphonse Jeannet (Zürich), Rudolf Staub (Zürich) and Maurice Lugeon (Lausanne). (double exposure!).

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