

MOUNTAIN-MAKING IN THE ALPS

BY

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ALB. CAMMERMEYERS FORLAG

IN MEMORIAM
OF
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Morten Johansens bogtrykkeri. — Kristiania 1908.

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INTRODUCTION.

The key to understanding of the mechanism of mountain-making is lying in the Norwegian mountains where we, in vast regions, only have three different series of rocks, granite, gneiss and phyllite.

The late Theodor Kjerulf considered granite as an eruptive which had lifted up overlying phyllite and partly "swallowed up" a part of it, while the gneiss-formation, his "Høifjeldskvarts," was lying above phyllite as the uppermost stratum. Brøgger who in 1875 and 1877 visited "Hardangeryidda" introduced into Norwegian geology the modern view of granite as an ancient Archaean rock, folded as a solid mass, in opposition to Kjerulfs younger granite, his "foot-granite." Above phyllite was lying the quartzite-gneiss-formation called by Brøgger "younger gneiss-formation." Ever since, Brøggers view has been accepted and Kjerulfs "foot-granite" is absolutely abandoned as a mistake. In 1893 Brøgger published "Lagfølgen paa Hardangeryidda" where he speaks of the younger gneiss-formation as partly sedimentary, crushed down to gneiss by a supposed enormous overlying mass of rocks, now removed by erosion.

A little later the Swedish geologist Törnebohm described the younger gneiss-formation as Algonkian (proterozoic), brought into place by an overthrust of up to 100 km. Recently Holmquist has proposed to solve the problem by underthrust. In fact, the problem is insolvable as long as the younger gneiss-formation is considered the uppermost stratum.

1906 I visited the "Snenut"-complex, east of the Suldal-lake, and found to my astonishment following facts : Archaean granite is a younger granitic eruptive, a foot-granite, and the so-called "younger granite" in the summits of some mountains, lying apparently above phyllite, is quite the same granite as in the base and was found by me covered with a small patch of phyllite, ergo lying originally beneath phyllite and now exposed by erosion. Phyllite was found to lie as a crust upon granite and partly upon the base of younger gneiss-formation, but never phyllite was found running through the mountain underneath the overlying strata. The younger gneiss-formation is Algonkian (proterozoic) and was in fact lying below phyllite but above granite. I found yet small patches of phyllite lying upon the younger gneiss-formation in its upper part, but for the rest phyllite is entirely removed now by erosion and the younger gneiss-formation seems apparently to lie above phyllite.

We are accustomed to find small fragments of Archaean gneiss imbedded in granite. But how is it possible that gneiss in the summits of mountains, often of vast extension, is real gneiss from Archaean series, and how has gneiss happened to come up in the summits? Geologists only know two methods of volcanic action, the present volcano and volcanic action along a fissure of the earths crust as in Iceland in 1783. The third method of volcanic action, being the foundation of mountain-making in ancient times, is quite unknown. The supposed contraction by cooling of the earth breaks up in often very large flakes the crust of the earth in points of weakness and thus gives rise to eruption of underlying magma. The sinking-in of the crust forces out the magma which carries along with it the loose-broken often enormous flakes and drives them up in the overlying uplifted sedimentary strata. In case of extrusive eruption the overflowing magma covers the surroundings, but at the same time its force is lost. If the eruption is only intrusive, the force is keeping on and the result is a piling-up of rocks, a mountain-making action more or less according to the force. There is absolutely no difference between the making of mountain-chains and plateau-mountains. The mechanism is the same in the Alps as in the Norwegian mountains. If the eruptive force is less, the overlying sediments will be lifted up and curved without

breaking to pieces as in the Jura Mountains. In my eruptive method of mountain-making the required force is distinctly divided in two components, the one the contraction of the earth with breaking up of the crust and the other the eruption of the magma as a pure consequence of the first force. The force required is undoubtedly here much less than the force required for "das Horizontalschub," whether this is in action from two sides (A. Heim) or only from one side from south (Schardt—Lugeon).

In Norway loose-broken Archaean gneiss and quartzite is by granitic magma forced up into uplifted phyllite and erosion has produced the apparent overlying of the younger gneiss-formation above the phyllitic formation. It is impossible to explain the mountain-making as long as the modern stratification is maintained. My eruptive explanation removes all difficulties. As a result of my observations I am tempted to say that all real gneiss, wheresoever it is found, is of Archaean origin and all real granite is but younger granite.

I am only a dilettante in geology. I am physician, born 1844 and was more than 60 years old without the least knowledge of geology, when in the end of January 1905 the widow of Theodor Kjerulf, on the hospital, presented me with a little popular booklet on geology. From that time I turned a strenuous student of geology, literary and practical. The reason, why in the mountains in 1906 I saw what I saw, was perhaps my imperfect knowledge; I had never read an Alpine work, and Kjerulf was obsolete. Afterwards I have studied both Norwegian and Alpine literature to see if my doctrine was right or wrong. Everything has convinced me that I am right, but at the same time I saw evidently the horrible consequence. Anyhow, the truth is the truth and I must fight my battle and go perhaps begging through the world to be heard. If my opinion is right, the last 30 years doctrine on mountain-making &c. is wrong. The regional metamorphism, dynamo-metamorphism or whatever You might call it does not exist, it is but contact-metamorphism. The working out of valleys only by running water is impossible. The fabulous erosion and, on account of it, the fabulous length of geological periods have never existed. In short, it is a formidable geological revolution.

The saga of the despised volcanists is not ended. They were right in the main but unfortunately did not understand the whole truth. Studers "Erstarrungstructur" of granitic magma was easily refuted. But because the volcanists erred in many respects the compressionists, as I might call the moderns, were not right.

I have preferred to write on mountain-making in the Alps as the Alpine literature is so large and more familiar to foreigners. Never having been myself in the Alps, I stick solely to what the authors themselves have written.

MOUNTAIN-MAKING IN THE ALPS.

Albert Heim : Der Mechanismus der Gebirgsbildung. 1878.

The author of the modern doctrine on upheaval of the Alps is undoubtedly Alb. Heim.

On the way of pure observation and remote from every hypothesis Heim will show that the Alps rose not by eruption, not by local sinking or upheaval, but by shrinkage of the earth's crust as a system of folds, that accordingly a tangential thrust was the mountain-making cause. Several times he tells expressly that he is founding his opinion upon nature while the volcanists only made hypotheses. Where the nature does not support his opinion (for instance "Brigelsehörner"), it is but local and of no consequence. Nature is nothing but Heims hypothesis is all and has been fatal to geology. Geology is yet in her childhood and her present mistakes are worse than Werner's. But when will it be acknowledged? I have long ago learned that no man is an authority.

I saw immediately that Heim must be wrong, but I could not find his chief failure. Three times I read his book and the third time I wrote plenty of notes to be able to get a general view. Yet I could not find the fault, but reading my notes I at once saw it clearly. It seems so satisfying when Heim writes: there can be no eruption of a magma because no veins are found

in the sediments nor any contact-metamorphism. You might say : but Heims view is already abandoned! To me it appears to be a very little difference between Heims folding and the enormous overthrust which in reality is an overfolding. The principal point in both cases is that solid rocks have changed place as a solid mass, whether as potters clay or plastic lead doesn't matter. The overthrust is perhaps more foolish, but at any rate both are impossible. These soap-sud bubbles must burst. |

Heim is quite right, denying the possibility of Studer's explanation of gneiss as "Erstarrungsstruktur" of granitic magma, but this mistake of Studer is no argument to the truth of Heims own theory. It is also true that all rocks except granitic magma and its differentiations have changed place as a more or less solid mass, broken to pieces or curved, but the cause of the pliability is heat, transferred from magma, and not pressure. Heims chief mistake what he himself was not aware of is his reiterated assertion that the centralmassif sends no veins into the sediments nor produces any contact-metamorphism. His statement of marmarosis in "das Sântisgebirge 1905" I will pass by. His mistake is that he always reckons the sediments from the base of Mesozoic strata upwards and quite forgets that all the Palæozoic strata are lying in the centralmassif. It is here in Verrucano and Anthracitschiefer, in the whole Palæozoic system, that contact-metamorphism and veins are to be found to such an extent that Heim says : it is impossible to entangle these strata on account of their altered condition. Here lies the principal argument of the eruptive origin. The magma was always intrusive, never extrusive, for no lava-streams are found. Everywhere is granite and its differentiations, but of course a part was already consolidated rocks when the vast magma broke out in Tertiary time. This magma is now partly covered by Palæozoic and Archaean rocks and younger sediments. Heim says : Røth lies either upon Verrucano or directly upon gneiss, both with steep fall and often with down bent more horizontal heads of outcrop, while Røth and younger sediments lie more horizontal. In the boundary between centralmassif and Røth great mechanical alterations have taken place as bent heads of outcrop, crushed breccias kneaded together, &c. The rocks of the centralmassif are driven violently up into younger sediments.

In his dynamo-metamorphism Heim excludes every action of heat as no evolution of heat could exist in the folding, pressure was the only cause. Lately besides pressure Schardt speaks of heat and Schmidt even of heat and dissolving agents, but none mentions the origin of heat. In the metamorphism heat is indispensable, I suppose, and here derived from the magma.

Heims reasoning is : "the turning point in all explanation of the rise of the Alps is lying in the upheaval of the central-massif and its relations to the folding of the sediments. The obscurity culminates in two questions. Has an active eruption lifted up the centralmassif while the sediments were passive or has a force, passive to both, done the work? Both theories seem to differ from the facts, but the contradiction can only be a deficient knowledge. Because our science at present makes a third theory almost unimaginable, the contradiction of one of these theories may rather be apparent; the contradiction will be solved. In this hope we are going to make our investigation."

This argumentation is rather sophistic, the third theory is my own eruptive one, only a further improvement of the first theory.

Heim asks why veins never run into the fissured limestone formation? The cause is the intervening gneiss and Verrucano which were lifted up in a solid condition and not at all as an eruptive. In case of eruption, why are no covers lying in valleys or higher up, asks Heim, not at all understanding the intrusive character of the magma. Knowing but the present action of volcanos or fissures, he cannot realise the possibility of forming mountain-chains by eruption. The supposed absence of any centralmassif in the Jura Mountains is but a mistake as the eruptive force, being less here, only lifted up and folded overlying sediments without breaking through; no centralmassif appeared at the surface.—Stapff's observations in the Gothard-tunnel seems to suggest that several flakes of gneiss are imbedded, in different positions, in consolidated granitic magma. The position of real gneiss and granite in the centre of centralmassifs or in deep interne kernels speaks in favour of eruption.

Studer in fact did not understand the real nature of eruption, but his mistakes are no arguments in favour of Heims

folding theory. "Why are such apparently separated patches of sediments, parallelly imbedded in gneiss, so often observed, while nowhere is found even once in the Alps a separated patch lying obliquely in gneiss?" In solid gneiss this could never occur, gneiss was not fluid or pasty as Studer supposed. "Why is it but larger plates, presenting small groups of strata, and not fragments of all forms and dimensions like Silurian fragments in post-Silurian granite near Christiania?" Because very large solid flakes of gneiss and Verrucano were driven up into the sediments by the magma which did not reach the younger sediments. "Are not such patches in the Alps much more likely to be the innermost kernels of narrowly pressed troughs, and Verrucano- and gneiss-rocks, wrapping round these, in the same manner yet parts of the troughs, while the arches, uniting them with rocks of the same facies, are gone and the connection with higher lying sediments is broken off?" It is but the last remains of asunder broken layers and not at all troughs and erosion. "Is it not the lowest strata of the limestone formation, separated in patches by movements of the centralmassif and squeezed by its rocks?" Certainly gneiss and Verrucano, driven up by the magma, broke asunder the limestone formation which partly was left between these uplifted layers. "We must at last remember the quite similar almost puzzling amalgamations within surely determinable sediments." The cause is the same, a mutual squeezing. "Baltzer has seen patches of limestone in gneiss and patches of gneiss in limestone. That would be inexplicable, if gneiss was formed from eruptive granitic magma, as Studer says, and consequently it proves the mutual squeezing in the contact." All what Heim has told is quite true, but to prove the impossibility of Studers absolutely false suppositions is of course no proof against my eruptive theory nor in favour of Heims folding one. In exceedingly many places of the centralmassif Heim has found sediments, without being able to prove their nature as deep troughs, what is quite in accordance with my theory.

At least Palæozoic if not even younger sediments are a not trifling part of the centralmassif, says Heim, and yet he always speaks of centralmassif in opposition to sediments (Mesozoic and

younger), which horrible mistake is the origin of so many mis-statements.

“In the eastern Alps Verrucano lies concordant to sediments as the deepest stratum, but only where the centralmassif is missing.” The truth is that the “missing” centralmassif lies hidden underneath. “Verrucano is cut off from the base of the limestone formation and thrust into the centralmassif by strong centralmassivic movements; but Røth lies often directly upon gneiss, while Verrucano only exceptionally comes discordantly in connection with Røth.” That is not a sequence of folding but of gneiss being driven upwards through Palæozoic strata. “At the same time Verrucano has undergone a mechanical structural deformation whereby conglomeratic structures are altered to schistosity; many Casanna-rocks are possibly crushed Verrucano. The upper Jurassic strata never lie centralmassivic and granitic gneisses never sedimentary; between these extremes is found partly centralmassivic partly sedimentary position. At present it is not possible to say what in the centralmassif are sediments or what mechanically altered old crystalline schistose rocks.” The magma has produced all these disturbances and a contact-metamorphism; a dynamo-metamorphism has no legs to stand upon.

“The volcanists’s view of centralmassif as active and of sediments as passive must demand a pushing aside of sediments, a folding of the limestone formation. To eradicate this error will take a long time. The relations in stratification shall make an end to this opinion; but first we must insist on more respect for erosion.” Most unfortunately to the fate of geology Heim realized his intention.

In Studers case (Vol. II, p. 169—72) the lateral pressure of the centralmassif must produce dilatation and breaking up of overlying sediments, but the massif limestone formation shows no signs of dilatation and as a consequence no breaking up took place. Erosion was according to Heim the cause of the exposure of the centralmassif. A longitudinal breaking up is insisted for in Studers case instead of the present indistinct direction of fissures. Clivage in the massif Røth must be demanded but is not found. Accordingly it is folding. All these supposed proofs in favour of Heims folding are but wrong. In the contact (Vol. II, p. 178—82), where sediments (Mesozoic) lie horizontal discor-

dantly upon the steep schists of the centralmassif, Heim knows a multitude of signs indicating great violence and squeezing with frequently confused structure. However, this is not produced by folding but by the violent eruptive pressure from below and contact-metamorphism from transferred heat. Granite is never altered by compression to gneiss but to gneiss-granite, nor to Verrucano. In the Alps as in the Norwegian tableland both a horizontal and a vertical movement took place.

Heims assertion that he in his chain of reasoning never has insinuated a hypothesis but only observed the visible earths crust is not true. He has always passed by the nature when it spoke a distinctly contrary language. And yet he says : "das einzige Zeugniß, auf dass ich mich berufe, ist der Vergleich mit der Natur." Ten years he was meditating the problem of "Brigelsers-hörner" and could not understand it, yet he rested satisfied with "Faltung der Falte." He left his "Rubicon" alone.

The packing in the middle zone of the Alps, where erosion is supposed to have been enormous, was long ago brought to an end while folding in the Jura Mountains was going on. This mistake is founded on the supposed minor erosion in the last mentioned region. The highest mountains are the most strongly denudated and accordingly the uplift of the folding has worked faster than denudation. Heims folding with rupture, so seldom in comparison to folding without rupture, is but a mistake. As I just to-day found this scientifically treated in dr. Ernst Weinschenks "Grundzüge der Gesteinskunde," I will refer to him. Weinschenk has come to the same result, only contact-metamorphism. If he had seen our Norwegian mountains where the key to understanding of mountain-making lies he might perhaps accept my theory.

Heims doctrine of the plasticity of rocks (Vol. II, p. 32—99) seems to me a real death-stroke to his folding theory, so unreasonable is it. The necessary enormous load of overlying now denuded rocks, demanding enormous denudation and consequently enormous length of geological periods, all that has never existed. The work is done by pressure alone as we know of no sufficiently powerfull heat and never can prove such one, he says. Neither heat nor water is necessary in his dynamo-metamorphism. "If my observations are correct, there lies in the material of the

mineral grain itself a true plasticity." This plasticity does not exist.

Granite, gneissgranite and differentiations are present in abundance; "massive" gneiss is probably very often granite and gneiss & granite are melted together. Of course all real gneiss is of Archaean origin. Stock-veins or sills are no proof of eruptive origin and real veins are seldom found, says Heim; but nevertheless he cites not so seldom examples of veins. In Mesozoic strata Escher has but mentioned one case. Heim postulates that no veins are to be found in the sediments which always are reckoned from Røth upwards. Of course gneiss and Verrucano cannot as solids send out veins and I have never by Heim found Røth and eruptives in immediate contact. As a consequence veins are to be sought in the centralmassif itself. "Formerly are mentioned granitic, syenitic and dioritic veins in gneiss and other crystalline shales but never in Røth. Quite similar veins are known from thousand other places in the Alps referred by Escher, Favre, Studer, Theobald and many others, but never run these veins into sediments and consequently are they older." The numerous eruptive veins in the centralmassif prove the eruption in Tertiary time, but of course there are also older eruptives, dislocated passively in a solid condition, as for instance the Porphyry in "Windgälle."

Metamorphism, particularly in the centralmassif, is mentioned in many places. It is a question if it is possible to find lawfulness in the confusion of Casanna-rocks, says Heim. The description of Casanna impresses the idea that flakes of gneiss and Verrucano are confusedly mixed together with eruptive magma and strongly metamorphosed. Angular fragments of gneiss are often found in amphibolitic rocks. The crystalline rocks of the centralmassif are perhaps to a great extent of sedimentary origin while Studer considers them eruptives. Theobald says: who can be in doubt of the upheaving action of crystalline rocks in Limmerboden? But Heim adds: Theobald has mistaken cause for effect. "Randkette" consists of younger sediments and the covering sediments to the east are strongly riddled. Everywhere packing of sediments (younger), never fissures as supposed by volcanists; but that mistake is acknowledged in "Das Sântisgebirge 1905."

A most prominent feature in the Alps is the many manifestations of violent force to be seen everywhere, not caused by folding but by eruption. Meanwhile it must not be forgotten that the magma hurled solid gneiss and Verrucano up in solid younger sediments, and consequently a breccia here cannot be a "volcanic" breccia. Pre-eminently is mentioned "the effect in the boundary line between centralmassif and sediments (Røth), where is found a most striking folding together of Røth, Verrucano and gneiss; many places is found a curiously confused breccia- or conglomerate-formation where gneiss and Røth are crushed into each other, having a different aspect from a volcanic breccia." Some places Røth contains fragments of quartz and Verrucano, partly bilding a breccia. Very often Røth lies directly upon gneiss where the gneiss is driven through Verrucano. The younger sediments, too, have been exposed to mechanical violence. In Dogger grains are crushed, Malm partly altered into marble, Eocene crushed and folded to such an extent that a certain stratification is impossible to fix, partly a confusion. In "kleine Windgälle" Dogger, Malm and Eocene are wedged into each other quite incomprehensibly, "but it is only local without interest for the whole." At „Fugeli" all sediments are inverted. Disturbances in the centralmassif is formerly related. From Heims exposition must be concluded that gneiss and Verrucano have been broken up and pressed into the overlying limestone formation in a most violent manner and metamorphosed. Studer (1873) considers the confused stratification of the centralmassivic schists in the contact as caused by pressure from the overlying sediments, but Heim asks, why the deeper strata generally show no crushed folding. Heim is a keen observer of Studers mistakes but not at all of his owns.

In Glärnisch "double fold" Verrucano lies highest, sometimes as a cap, lower down limestone bands, and lowest all is Eocene. According to my eruptive theory Verrucano is driven through the overlying strata and Eocene, gliding down, filled the valleys. This simple fact has caused much controversy but of little interest.

The very often mentioned metamorphism in the Alps is by Heim regarded as a dynamo-metamorphism while, in fact, it is a contact-metamorphism, principally to be found in the central-

massif where the eruptive magma is lying and where it has produced its chief action. In the younger sediments too it had its effect by transferred heat. "Lochseitenkalk" is a strongly mechanically crushed and metamorphosed "Hochgebirgskalk." Escher has accentuated that the "Hochgebirgskalk" near the centralmassif has undergone a later deformation which he ascribed to the crystalline rocks (i. e. the magma). Several places Heim speaks of marmoration of limestones. He says : it is quite irregularly distributed, independent of the vicinity of the centralmassif; the marmoration, of course, cannot be caused by the centralmassif, though we are not yet enabled quite precisely to tell the cause. Escher speaks of the marmoration of limestone in the Gothard-tunnel, while in other places it is not metamorphosed and yet lying at the same distance from the same feldspathic rocks. Escher does not distinguish between magma and really solid rocks. Studer says : in "Roththal" is easily found, in the middle of granite, a some lines thick limestone without a vestige of plutonic action. That is strange, the piece of limestone lies unaltered in a consolidated magma. I cannot explain it. A. Geikie says that the absence of "chilled" edges of a vein may be due to the high temperature of the rocks into which the granite was injected. Heim asks : is it not clivage which in the Alps so painfully has effaced the mechanical metamorphism of rocks? Is there in the centralmassif yet to be found rocks which have not undergone a textural modification by crushing? The metamorphic question in the Alps is even to Heim a most puzzling scheme.

Contact-metamorphism is traced until nearly 10 km. from the intruded rock (magma), near Christiania about 2—3 km. Why, then, is not the whole Alpine region metamorphosed? I cannot agree with this statement of geologists, here must be a misunderstanding. For instance, 9 km. from the intruded *visible* magma the effect cannot be ascribed to this visible magma, but the magma must of course be lying underground, invisibly, far off from this visible spot, perhaps 9 km. apart; then, the metamorphosing effect is acting from this underground magma, but how deeply underground it is lying is of course impossible to tell. Ergo we cannot at all tell in what distance a magma is able to act contact-metamorphosing.

Another great mistake is that the sediments run right through a mountain and so the higher lying stratum rests only upon the lower lying stratum, while in fact the sediments lie only as a crust outside the inner nucleus of mostly crystalline central-massive rocks and older sediments. "Below the whole 'Grosse und Kleine Windgälle' the Eocenic sediments run and above and below these the sediments lie in inverted or normal succession."

Yet another colossal mistake, inevitably leading to the hypothesis of enormous geological periods, is Heims formation of valleys exclusively by running water. The valleys are formed by upheaval of mountains, leaving an open space between. The bottom of the valleys is also heaved up but to a minor degree, while the flanks were protected against the extrusion of the magma by strata, thrown aside and now partly eroded. The running water has only carved out its own bed.

From the Glacial Period geologists reckon about 9—10 000 years and a similar standard must be applied to older periods. Time and erosion from middle Tertiary time is not at all so large as supposed on account of the many failures. The supposed overlying cover of rocks up to 10 000 m. has never existed and, of course, the time necessary to its erosion must be excluded. Another important failure is the usual calculation of the thickness of strata. Chamberlin in his geology has much reduced this calculation, but has not seen the real cause to the miscalculation. A stratum may be compared to a book, lying on the table, in which case none can mistake the thickness; but when the book stands in the shelf its thickness is the same. A stratum raised up by a magma is of the same thickness as in its horizontal position. We must never forget that an upraised stratum is always only a crust outside the nucleus, and its thickness is not measured by the perpendicular line between its highest and lowest point. The result must, then, be quite erroneous and the required erosion erroneous too.

Heim twice mentions the origin of the folding theory as coming from America, but he never tells us the names of these American geologists.

SUMMARY.

The volcanists's wanting understanding of the real nature of eruption and their consequent mistakes served the posterity as perfectly valid evidence of eruption having absolutely nothing to do with formation of mountain-chains or plateau-mountains. In that way every possibility of understanding was at once cut short and the posterity was constantly walking farther on the devious ways which never could lead on to the truth.

The volcanists's mistakes do not prove the correctness of the compressionists's yet wronger suppositions.

Heims assertion that the centralmassif sends no veins into the sediments nor produces contact-metamorphism in these, this being a chief argument against the eruptive theory, is an unhappy great mistake, how plausible it may seem in the beginning. The eruptive veins and the contact-metamorphism took place just in the centralmassif itself, while Heims sediments refer but to Mesozoic and younger strata. To the centralmassif belong, besides granite (new and old) and its differentiations, both Archaean gneiss and all the Palæozoic strata, Verrucano; just here are found very prominently veins and contact-metamorphisin. It is of less importance that in Heims sediments is also found metamorphism, the heat of the magma being transferred.

In Alpine tunnels are fragments of younger sediments, dropped down and incorporated in the magma, contact-metamorphosed by it. Everywhere are related signs of great violence. The latent plasticity in the mineral grain, folding solid rocks as potters clay, and the enormous strength of the tangential thrust, working for long periods, are but impossibilities. The overlying immense load of rocks, necessary to explain latent plasticity, and its erosion did never exist. All dynamo-metamorphism, produced by pressure without heat and moisture, is unreasonable.

My eruptive theory explains matters in a simple natural way.

Here is only demanded a vigorous effort of short duration when the contraction of the earths crust broke up a less resistant region, a weak point in the crust, in flakes of more or less extention. When this is done and the crust is sinking in, a new upheaving force is produced by the magma which, finding no room in the less voluminous interior, is driven out and upwards

through the fissures, pressing the fragments up into the overlying strata or quite through them. Under the upheaval of the Alps the eruption was intrusive, never extrusive.

The centralmassif never reaching up to the surface in the Jura Mountains, the overlying younger strata are but folded, while the Tertiary less consolidated strata mostly slid down in the troughs. In the Alps the eruption was much stronger and drove up gneiss- and Verrucano-flakes to the summits, throwing aside the younger sediments. This force was certainly no small one, but yet smaller than the force demanded for Heims folding. Here the force is divided in two separated components, tangential thrust breaking up the crust and magma producing the upheaval, while Heims folding has but one force "das Horizontalschub" doing the whole work and lasting for an immense time.

Practically spoken, it was one violent eruption at the same time, but during the sinking in and adaptation of disturbed strata there probably were smaller eruptions as long as the fissures were permeable. I speak of fissures but of course it was rather big gaps. These supposed successive eruptions might perhaps explain many strange facts in the Alps. The immense magma must have kept on cooling for a very long time.

Younger sediments were thrust aside, partly sliding down in the valleys, sometimes broken quite loose and tumbling down in yet younger strata in normal or inverted position. The following erosion has laid bare older strata even uplifted gneiss and Verrucano or granite. As a natural consequence we find veins, dykes, sills and contact-metamorphism in the centralmassif. Crushing, rolling out, sliding, faulting, brecciated deformation are but natural phenomena. The bending, "folding," of younger strata is an effect from transferred heat in connection with local properties of the strata during the violent action. It cannot seem strange that contact-metamorphism from this immense intrusive magma may be to some extent different from the common acknowledged contact-metamorphism. The regional metamorphism, the dynamo-metamorphism does not exist, it is quite a mistake. But it may be possible that a previous crushing has some influence on the metamorphism. No immense overlying load of rocks with consequent erosion, no immense erosion of valleys

nor any immense length of geological periods are demanded here. Mountain-chains and plateau-mountains are formed in the same way by eruption.

Albert Heim : Das Säntisgebirge. 1905.

After the lapse of 27 years Heim yet sticks to his folding, with his usual dexterity maintained in the middle highest part of the mountains, while his two assistants with great difficulty manage the folding in the Western and Eastern parts.

Meanwhile Heim is gone over to Schardt-Lugeon's gigantic overthrusts. "Das Säntisgebirge" is swimming upon Flysch, detached from the remaining southern Jurassic substratum and transported northwards without any trace of the Jurassic system, but still «das Säntisgebirge» has undergone a regular folding afterwards as it met with a northern resistance, causing all folds to overlap towards north. The cause is the tangential thrust, a *deus ex machina*. What the resistance was I cannot imagine, it must have been an exceedingly strong one. In his last paper from 1908 Heim says that the resistance to the overlapping in the Alps was the sub-Alpine Nagelfluh, already pressed up. But as far as I know, there is no Nagelfluh north of Säntis and if so it must have been removed by erosion. Flysch cannot have been the resistance. I cannot see any real difference between the folding and the gigantic overthrust, except the latter one being more absurd. Both are alike impossibilities. In both the principal point is the same: the previously solid rock is moved in a similar manner, whether as folding or as gigantic overthrust-overfolding does not matter. As long as geologists absolutely reject eruption, they are cut off from understanding.

Of greatest interest are the numerous fractures and faults in the Cretaceous system, about 370 large ones mapped out, besides a multitude of smaller ones; seldom these run into the Tertiary strata. In 1878 Heim hardly relates fractures in younger sediments, but my eruptive theory must demand fractures here.

Chiefly Heim junior remarks that the metamorphism in the Cretaceous system is pronouncedly local, quite irregularly distributed in the mass, and consequently it cannot be contact-metamorphism. That is really strange. Perhaps more or less fine

fissures conducted the heat to different places, perhaps dynamical crushing, disseminated in the mass, was more easily metamorphosed. The other two contradictions to contact-metamorphism are but a mistake : the magma was in the depth and the underlying presumably not metamorphosed rock was not Flysch as lubricating material but hidden metamorphosed older rocks.

The Sântisgebirge was heaved up through Flysch, which was thrown aside and only partly remained upon the Cretaceous system, where it is now removed by erosion, as Heim says : "at one place is found an in-crushed piece of Eocene the only one in the Sântisgebirge". Lying far away from magma, Flysch is but little metamorphosed or not at all.

Arnold Heim junior writes : Lugeon has 1902 thrown a new light upon the Alps. Numerous formerly puzzling phenomena, insoluble details partly passed by in silence because of being unintelligible, all this is now combined to an uniform large building of a new kind. The new opinion has made the Alps properly more plain. Schardt-Lugeons opinion of the tectonics in the northern Alps is to-day the most plain and unitive one. Heim jr. tries, in a rather unsatisfactory way, to prove the rootless state of the Sântisgebirge in the western part, while Heim senior acknowledges to have found no proofs in the middle part.

The force is a tangential thrust from south. No radial movement of the crust is found. In the eastern part Blumer found the vertical fractures produced by a truly vertical sinking down of the eastern fragment, but Heim senior adds : it must be a substantial loss, a depression of the mountain, wherein the overthrust mountain sank down.

SOME CRITICAL REMARKS.

A breaking up of rocks on a great scale with many indications of a versatile violence, while Flysch, sliding easily aside, is less hurt and its possibly remaining rest on the upheaved Cretaceous system now eroded, all this speaks in favour of eruption. Blumers fragment in the eastern part is only a less

upheaved part, the rest having been exposed to a more violent uplifting force.—The eruption solves the many mysteries.

How can the impossible force from south be explained? And how explain the later folding? As long as the Sântisgebirge is swimming on Flysch, it cannot be influenced by the tangential thrust; the mountain must first grow fast to the underlying crust. I cannot find any trustworthy explanation.

A. Baltzer : Aarmassiv 1888.

In this work a multitude of observations pleading in favour of eruption is related. Some of these will be cited:

“The summit of Finsteraarhorn is Hornblende-schist and gneiss. Protogin-granite plays a leading part in the western Alps and in the northern and western zones of central Alps. The zone of granite in west is superposed by Sericite-gneiss. In a few cases there are lenses of gray gneiss in granite. Quite inevitably the idea obtrudes itself that the elements of rocks must have a considerable mobility through the whole mass. In Lauteraarhörner granite makes an impression of being kneaded into gneiss. Granite perfectly encloses sharp-edged fragments of Mica-schists. Granite in the contact with gneiss encloses pieces of the last. Gneiss, too, sends apophyses in granite. Steps of half-granite and Mica-gneiss and granitic veins, one believes himself to be in a granitic workshop. Both Rotondo-granite and the granite in Aarmassif send distinct veins in neighbouring rock (gneiss) and enclose fragments of the same. In the Gothard-group granite in the middle part remains most often in the depth, why gneiss is dominating. At the southern boundary an eruptive granite must be supposed to explain the phenomena of veins. Characteristic of the Oberwald-glacier is the veinous appearance of the granite.”

Here is found a large amount of granite, fragments of other rocks incorporated in granite, many veins and dykes. The want of contact-minerals may be explained by the intrusive character of the magma. My theory of eruption is calling for very extensive masses of granite.

Maurice Lugeon : Les grandes nappes de recouvrement 1902.

I had already begun to study Lugeon when I got Schardt's last paper, why I determined to make use of this more concentrated work. So I only refer to some remarks of Lugeon.

"One of the great singularities of the overthrusts in the Alps is the abundance of Flysch upon and in which they seem to have advanced. This region presents moreover breccias with exotic rocks. Little satisfactory is Schardt's explanation that this Flysch arose by destruction of the covers (les nappes), as they advanced in the Eocene sea. Lugeon's explanation is that the Flysch with exotic boulders is a terrain transported northwards by the large overthrusts like all the rest, but the Flysch was already formed with its present characters before the overthrust.

Everywhere in the Swiss Alps there is a crushing produced by a violent movement against the anterior Molasseland. The effect of this tremendous thrust from the interior of the Alpine arch has been of variable intensity, but always has it folded the Alps as the panels of a lying screen.

Overthrusts with Helvetic facies have realized to jump over the Hercynian "Horsts", while the central overthrusts are stopped by this barrier from which they are separated by the "Glanzschiefer", here playing the part of a secondary Flysch. The pré-Alpine overthrusts have realized to overcome the distance and perhaps the resistance, accompanied by the immense fascine-covering of Tertiary Flysch. Doubtless formed under the same conditions of pelagic sedimentation, Mesozoic "Glanzschiefer" or "schistes lustrées" and Tertiary Flysch have played the same rôle in the tectonic manifestations. Perhaps it is but a coincidence, perhaps the result of a yet unknown phenomenon."

The singular abundance of Flysch is only a mistake, the Flysch is not at all so abundant. Neither Tertiary Flysch nor Mesozoic Flysch is lying below the rocky covers as a lubricating material. All the immense overthrusts are absurd, the jumping over the "Horsts" and the wanting in doing so. Why stop the central overthrusts before the "Glanzschiefer", the lubricating material, without sliding further? How can Molasseland be a barrier to overthrust?

**G. Steinmann : Geologische Probleme des Alpengebirges.
1906.**

“It is impossible to present to the laity in an intelligible form still disputed problems, it must be what is fixed in its fundamental lines. Yet to-day we cannot understand completely the whole mechanism of mountain-making whose cause is only a hypothesis.” Molasse is lying in the troughs of the Jura Mountains, the upheaval here being moderate, and in “Schweizer-Mittelland”, but not in the Alps where the violent upheaval threw aside Molasse and erosion has removed what was remaining on the mountains. “The Alps are sometimes very little folded as in the northern “Kalkalpen”, east of Rhine or in the southern Tyrol where we have rather a plateau-mountain than a mountain-chain. The want of the formerly so extensive sedimentary cover shows the large erosion.” (2’)

“Upwards on the giants of Oberland until some hundred metres below the peaks Jurassic limestone is lying, but at the base and in the peaks, quite unexpected, we find old crystalline gneiss-granite. In the precipices of Jungfrau (fig. 6) the limestone forthes its way through the gneiss-granite as a large wedge, where the limestone in the length of about 3 km. has the gneiss lying above and below; the lying trough is unmistakable, the gneiss is folded over the limestone.” How is it possible to explain in such a manner? The eruptive granite from Tertiary age is called old gneiss-granite, even gneiss. The limestone, lying as a crust outside the granite, is supposed to go quite through the granitic mountain and the granite to be folded over the limestone. The limestone is but a remaining rest of the overlying uplifted Jurassic system. When geologists can print such absurdities they may as well tell us that the moon is made of an old cheese.

“To comprehend the power of folding look at the indentation of gneiss in limestone in Gstellhorn, only to be explained as the end of a gneissic fold. Fig. 7 shows what quite prodigious forces have been at work to knead two such friable rocks into each others as it was potters clay.” Hardly one does not know whether to cry or laugh! To such impossibilities leads the absolute rejection of any eruptive force. Steinmanns gneiss is probably at least for a great part granite.

“In Mont Joly (fig. 8) the tableformed building is not a want of folding but to the contrary an exorbitant folding, showing the law that the strongest folding has been at work where the stratification is most quiet.” How curious! the simple fact is that here no folding took place.

In fig. 9 Lias lying between 5 strata of “Riffkalk” is but a small real overthrust, produced by upheaval and heat from the magma. In Glärnisch has never been any folding overthrust of 30 km., only upheaval.

“Mythen (fig. 11) stehen wie hergezaubert da.” “These mountains partly with inverted stratification look like tormented, to such a degree are they pressed and crushed, the rocks thrown about irregularly.” Here has a violent action been at work. Never having been in the Alps, I cannot tell whether upheaval alone brought them in situs or a tumbling down from other higher uplifted strata planted them as quite separated fragments rootless in the Flysch.

“East of Mythen at Iberg are found foreign exotic even crystalline rocks. ‘Die Klippen’ were formerly explained as driven up from the depth, but this explanation showed itself unsatisfactory when in Sihlthal the underlying stratum was found to be limestone. It is the last rests of a denudated over-arching cover. As in Glärnisch not single mountains were transported, but folds were extended to closed covers.” Such enormous denudation never existed, the sediments are only external crusts and eruption is the cause. The sub-Alpine Nagelfluh, explained as a rest of this cover, which is impossible, must be explained by upheaval of older consolidated rocks. “Die Voralpen” will be mentioned later in H. Scharlts paper.

In the Simplon-tunnel was found strata of schists and limestone in gneiss. Neither the folding- nor the overthrust-theory is able to tell what is to be found in a tunnel. The geologist seldom makes a pure distinction between real gneiss and real granite. Schists and limestones are fallen down in the magma from above and gneiss is lifted up by the same magma, both sometimes as colossal fragments, a quite natural consequence of eruptive upheaval, where the granitic magma incorporated the solid rocks in its mass. The supposition of the Simplon and Monte Leone as rootless swimming on the schists is false.

The new theory of the colossal overthrust from south until 50 km. with only a few refoldings is but a physical impossibility. It does not matter that the overthrusts took place horizontally.

“In the eastern Alps the Lepontic cover dips under the east-Alpine cover of granite and gneiss in a length of 40 km. with some windows (‘Fenster’), where the Lepontic cover is laid open by erosion of the crystalline masses. There are overthrusts of until 120 km.” An unreasonable mistake! The crystalline rocks are thrust through the sediments and in the windows the upheaval was less; the crystalline rocks are still lying in the depth.

“The erosion began as soon as the upheaval of the Alps about middle-Tertiary age took place and the highest places were denudated most.” How is it possible to believe in this colossal erosion only from Tertiary time? “Bündnerschiefer” is only sediments, left during the upheaval in depressions between more uplifted parts.

“Thus in proper places the covering construction of the Alps is unveiled in the most evident way. The rocks are to an incredible degree distorted, rolled out, torn asunder and kneaded together. In this way a multitudes of problems are cleared up.” That seems out of the question.

“In the southern Alps is yet missing the possibility of a south-Alpine cover, lying formerly upon the eastern Alps. Here is some peculiarity, folding and overthrusts turning southwards and a great volcanic activity. Perhaps the Dinariden-problem will be solved when we have succeeded to discover the cause of the Alpine overthrusts.” Certainly, if it ever is possible to find any cause of the overthrusts.

SOME CRITICAL REMARKS.

At the end of his paper Steinmann professes our ignorance of the cause of the Alpine overthrusts which are not yet acknowledged from all sides as a fact, he adds. Is it then really a fact? The southern Alps speak rather against him and in favour of my eruptive theory. The colossal overarching cover and its

erosion, the local sinking of the "Préalps," the potters clay and swimming of superior strata upon inferiors all this we have no use for.

In the mountain-making there was only one phase, the eruptive period, not at all two as Steinmann says : first a large overfolding cover, then a long interval and at last a later folding of the overfolded territory during which the proper upheaval of the Alps took place.

H. Schardt : Moderne Anschauungen über Bau und Entstehung des Alpengebirges. 1907.

"Schardt's present view is folding covers piled up, the one upon the other, and often lying far away from their original "rooting ground". The overthrust is always from south, some local exceptions easily explained by back-folding. A certain considerable amount of crystalline rocks must be explained even as metamorphic sediments. As a fact must be accepted that sedimentary masses, incarcerated between deep crystalline folds in consequence of huge lateral pressure and overload of up-piled rocky masses, must move physically and chemically, pressure and heat playing a certain part.

The so-called "Glanzschiefer" separates the northern gneissic zone from the southern which latter consists of northwards sinking lying folds of gneiss and for a very material part seems composed of granites. The different gneissic covers are mostly separated by Mesozoic sediments. "Glanzschiefer" and "Bündnerschiefer" have got a schistose structure from tectonic-metamorphic cause. The striking and bounding of the forming Glärnisch cover against the Miocene Nagelfluh caused differential pressure and overarching. The eastern crystalline massifs consist of stupendous masses of granitic and crystallo-phyllitic rocks besides different greenstones and sediments.

In the Préalps is lying reckoned from Molasseland southwards:

- 1) Schistose Flysch with infolded and incarcerated Mesozoic fragments in a very confused condition.
- 2) Gurnigelflysch partly schistose partly coarse-grained sandstone with exotic granitic débris.

- 3) Median Préalps or the Limestone-chains where a broad syncline, filled with considerable Flysch, lies between their external zone with complete stratification and regular folding and their internal zone with frequent faults, overthrusts and scaly deformations. In the whole circuit the sediments lie abnormally with the oldest strata upon Flysch, whence is concluded : ergo rootless.
- 4) Niesenflysch often strangely folded and consisting of frequently schistose Flysch, sandstone, coarse breccias and exotic débris.
- 5) The Saddle-zone with Helvetic facies, characterized by schistose Flysch and numerous very complicated enclosures of Mesozoic strata. The older stages are more prevalent. The Mesozoic débris originate here, as in Gurnigelflysch, from the Mont Bonvin—cover and must partly be ascribed to remaining débris of the Median Préalps.

The different zones are presumably connected beneath the Median Préalps, 1) with 5) and 2) with 4).

The uppermost Hornfluh- & Chablais brecciated formation with fragments of Trias, Lias and the Cretaceous system besides crystalline exotic débris is the remains of an earlier higher cover (Steinmanns Rhaetic cover) from a still more southern origin.

“Die Klippen” are remaining rests of an overthrust cover from Annecy until beyond the Rhine, a perpetuation of the Chablais-Stockhorn cover.

The conclusions, drawn by Schardt, is as follows:

It is a pronounced asymmetric structure derived from presumably originally symmetric folds which, compressed into bundles and advancing northwards, were piled always higher up. As a consequence of this overarching the folds slid down to the north and were stretched out longitudinally by the movement itself and by the overload of accumulated covers. The Préalpine covers from the southern gneissic zone, completely separated from their territorial root, emigrated along the Helvetic zones which originate from the northern gneissic zone. The Préalpine covers slid along the central syncline, the “Glanzschiefer,” and then along the Helvetic folds, before these latter were completely evolved, what is proved by incorporation of fragments from overlying covers between the Helvetic folds.

It is also evident that by-covers and frontal covers as well as the superficial folding of these upper covers took place first after their overturning, while sliding down to the north. Conformable to this is also the exfoliation of the Cretaceous system from the Jurassic folding-nucleus and the folding of this system independent of the Jurassic nucleus.

A simple sliding down of a sedimentary cover from a crystalline substratum in form of an oblique plane can give occasion to a folding-cover.

The evolution of Helvetic covers seems often to have taken place under increasing load what is well explained by the so-called "Klippendecken", moving along them, and also by the rising and overarching of one or more by-covers, when the cover bounded against a resistance.

The covers of Chablais-Stockhorn-zone have certainly their territorial root in the southern gneissic zone, where yet is found similar sedimentary remains and crystalline rocks.

The territorial root of the east-Alpine covers must be to look for still more southerly, near or beyond the Amphibolitic zone of Ivrea.

As the more southern earlier up-piled folds were sliding northwards over the northern in evolution being folds, they exercised certain influences upon the last ones. Thus the Chablais-Stockhorn-cover was acting as a press-roller on the Helvetic covers, while the mechanical deformation in these upper covers was very small.

The horizontal movement of covers, as well sedimentary as crystalline, was equally considerable except for the down-sliding movements, where the gravitation is the direct cause, what formerly often has been less noticed. Moreover the roots of covers are always very vertical, while the folds themselves are horizontal or even sink down headlong.

The present deep situs of the southern Alps is, as well-known, explained by the stupendous later sinkings in this region.

Scharlts last words in his paper are that rested on our present knowledge a truly paying work first now can be done.

CRITICAL REMARKS.

Being the foundation of the overfolding theory, the structure of the Préalps is cited at some length. Is the upheaval of these mountains done by eruption and not by overfolding, the Alpine mystery is solved. We must try to explain the upheaval of the Préalps by eruption in accordance with Mr. Schardts own description of the different zones and their peculiarities.

The eruptive magma never reached the surface but pressed up overlying strata into and through yet younger strata. The Mesozoic system with its crystalline eruptives, older than the upheaval, were pressed up through the Tertiary formation and is now partly by a moderate erosion brought to view. The upheaval was violent and broke up strata more or less. In this way might be explained at least a part of the débris, but it must at the same time be supposed that conglomerates and breccias existed in Mesozoic strata before the upheaval. Missing layers in the Mesozoic system is also to be explained by the violence of the uplifting force.

Of course Tertiary sediments must be expected to lie round the uplifted Mesozoic mass and in the syncline of this mass is still lying considerable not denudated Flysch. The Flysch is contact metamorphosed by heat, transported from the underlying magma, and if the distance from this magma was great, the metamorphisme was less or perhaps quite absent.

The loose uncompacted Molasse was partly thrown aside partly removed by later erosion. In "Molasseland" the upheaval was more calm and the stratification horizontal, but at the borders of the Préalps the upheaval was stronger and the stratification of Molasse was here inclined.

Where Mesozoic strata were pressed through Tertiary ones, the lower remaining Flysch must inevitably lie upon older Mesozoic strata, while the younger Mesozoic strata are to be found higher up.

The supposed connection of Flysch in zone 1) with 5) and 2) with 4) running underneath the Median Préalps is of course but a pure fancy and the Median Préalps are absolutely not "rootless".

The Mesozoic débris in Flysch zone 1) & 5) and the crystallines débris in zone 2) & 4) are only what was to be expected during the violent upheaval.

It might be that Flysch was pierced by Mesozoic strata and that a part of this Flysch rolled down during the upheaval and is now lying in the outer Flysch-zones, 1) & 5).

In the zone 3), the Median Préalps, the internal zone shows a more violent upheaval with faults and overthrusts, while the external zone was lifted up more calmly.

The highest part, the Hornfluh-Chablais-zone, with its Mesozoic and crystalline débris seems to be the most crushed. In its uppermost covers the metamorphism is very small, perhaps to be explained by the longer distance from the magma, while "this zone acted as a press-roller on the Helvetic covers" whose metamorphism might be explained by a position nearer to the magma.

"Glanzschiefer" and "Bündnerschiefer" are contact-metamorphosed sediments, left behind in the open spaces or valleys between much higher uplifted mountains.

To explain the dynamo-metamorphism Heim has only pressure, Schardts speaks of pressure and heat, while Schmidt later on mentions not alone pressure but as well increased heat and dissolving agents. But they do not mention what the cause is.

Why are the southern Alps sunken so deeply? My opinion is that they are not sunken at all. The supposed sinking everywhere in the world is no sinking, but in many cases it is only an upheaval of surrounding regions to some extent.

The necessary force in the eruptive theory is much smaller and even separated in two quite different components, the second only the direct consequence of the first.

Studer was right in the main in spite of his unfortunate mistakes which were the real reason of abolishing all thoughts of eruptive action.

To all the misstatements of Mr. Schardt & Co. I can only answer: how is it possible to believe it?

Carl Schmidt : Bild und Bau der Schweizeralpen 1907.

"It is very strange to find Tertiary strata in the upper-Rhenish Lowland, a sunken zone from old-Tertiary time.

Before Carboniferous time a series of sediments at least 20,000 m. thick accumulated.

“Bündnerschiefer” must be supposed to intercommunicate beneath the massifs. The projected Splügen-tunnel, no doubt, will solve this supposition. The Simplon-tunnel has disclosed an unsuspected complication but also afforded a satisfactory explanation of the mountain-making mechanism. The mountainous nucleus is not archæan gneiss but Jurassic calcareous slate. In the Albula-tunnel is buried a fragment of calcareous slate 750 m. beneath granite.

The mountains are ruins formerly overarched by a huge cover of rocks and now reduced by thousands of metres.

“Credo quia absurdum est” was the jocose answer of a Schwabian geologist, as the tectonics of “Walensee” were placed before him.

Yet to-day the opposition is not fallen silent. The overthrust from south of the exotic masses of the northern border of the Alps can be accepted as founded scientific theory. The whole phenomenon is a potentiated folding and the overthrust-cover a piece of a lying fold. The covers fill out old depressions. The overarching cover upon St. Gothard was once more than 10,000 m. thick.

At the end of Carbonaceous time gneisses and Palæozoic strata with their eruptives were folded by tangential thrust into the Variscian Mountains north of the median zone of the Alps which was not disturbed. It is a common phenomenon that extensive and energetic folding results in a subsequent eruption of volcanic magma from the depth. Many granitic rocks in the Black Forest, the Vosges Mountains, Mont Blanc-, Gothard- and Aarmassifs are then to be interpreted as a consequence of the Variscian Mountain-making. Of the extensive Variscian Mountains to-day but little is left, large masses are sunken into the depth and covered by younger sediments. Every uplifted mountain is eroded by water. The ocean spread again over regions where high mountains were raised up. Mesozoic strata covered the Variscian Mountains i. e. the whole central Europe. Later in Tertiary time the upheaval of the Alps took place while in Swiss Hilland and upper-Renish Lowland a sinking occurred.

In the Alps a tangential thrust-force, lasting a stupendously long time, was at work from south to north. These stupendous mountain-making changes demanded immense periods.

The mobility, on an extended scale, of the rocky masses is the essentials of mountain-making. Not alone clay-slates even friable limestones are curved, as if it was soft plastic lead. All the Alpine rocks are dynamo-metamorphosed.

In dynamo-metamorphism was at work not alone pressure (thrust) but as well increased heat and dissolving agents (overheated water with dissolved carbonic, silicic, boracic and titanitic acids). The mineral metamorphism is determined by the degree of profundity, for instance, the Mesozoic sediments were lying 15,000—20,000 m. below the surface, but erosion has brought them nearer the surface. In the central Alps Trias and Jura are crystalline on account of dynamo-metamorphism; if it really was contact-metamorphism, there must have been eruptions after Jurrassic time, but the proof is not at all yet delivered.

In the eyes of old geologists valleys were fissures, gaping rents in the earths crust; the moderns teach that running water and ice-streams formed them in perfect unconcern of the undergrounds nature.

Other warmly defended opinions lead into a blind-way threatening to strand the vessel.

The theory is everywhere pressing on into the front, intoxicates".

SOME CRITICAL REMARKS.

Lately in German language popular treatises of the Alps are en vogue, Steinmann, Schmidt and even Albert Heim. The time to revolt against these impossibilities has come too.

When modern geologists do not know what to do, a region is a sunken part as in southern Alps, Préalps, upper-Rhenish Lowland and Swiss Hilland etc. The sinking is but a less uplifted part and sometimes it is only the more elevated position of the surroundings which gives rise to the supposed sinking.

Sedimentation of at least 20,000 m.s thickness or an over-arching cover of 10,000 m. upon St. Gothard is but the common error in sedimentation and erosion. Erosion has not at all ruined the Alps.

Formerly is mentioned in the tunnels limestones, dropped down and intercalated in granite, and the impossibility of massifs resting upon underlying „Bündnerschiefer“.

„Credo quia absurdum est“ is in fact a crushing blow to the errors of the present geology. I am glad to hear that geological opposition yet exists even at the risk of stranding the vessel.

The story of the Variscian Mountains may be a pure fancy without any real truth, as far as I can see. When Schmidt says that it is a common phenomenon that extensive and energetic folding results in a subsequent eruption, the fact in itself is quite right, but Schmidt mistakes cause for result. The extensive eruption is the cause of the upheaval and not vice versa.

The stupendous long-lasting tangential thrust with all other fancies is an impossibility.

Mr. Schmidt demands quite rightly for metamorphism both heat and dissolving agents, but he does not tell and in fact cannot tell the cause of these. The demanded profundity necessary to dynamo-metamorphism never existed.

The valleys are formed neither by fissures nor by running water but by upheaval.

Albert Heim : Der Bau der Schweizeralpen. 1908.

This treatise shows that Albert Heim has left alone his old Gods and embraced the new ones who certainly are a real offspring of his old folding theory.

Only a few short abstracts:

“We must never forget that the Alps are a ruin and that the erosion has already worn off much more than still is at hand.

In the depth all folding was plastic without fracture. Chiefly in the upper covers are numerous vertical surfaces of fracture, but the displacement is always horizontal, produced by ‘Horizontalschub’; it is never real faults, primary vertical movements in the earths crust, which in the Alps never are found in any unquestionable case. All is speaking of horizontal movements.

30 years ago it was supposed that the Alps before the upheaval had the double breadth but now the quadruple-octuple breadth."

The missing of real faults may be quite in accordance with Heims theory but not at all with the real facts, I think.

CONCLUDING CRITICAL REMARKS.

Som time ago I red with great interest Studers „Geologie der Schweiz 1851—3", but for my special view there was little to be made use of. Studer as all volcanists did not see the real nature of eruption. He and all modern geologists know only the present volcano and eruption along a fissure. When Heim supposed eruption through volcanos as impossible to the upheaval of the Alps, he was quite right so far; but the eruptive upheaval was a large breaking up of the crust in a most extensive manner.

The formation af gneiss from granitic magma by Studers „Erstarrungsstructur" was absurd, and Heim was all right here too. But when Heim concluded from the mistakes of Studer that eruption was absolutely excluded and that his folding consequently was all right, this conclusion was also absurd. Meanwhile at the same time this conclusion put, in fact, eruption quite out of the question, unfortunately. It was now perfectly impossible to get at an understanding. Studer in spite of all his mistakes was on the right way.

The next mistake of Heim was his statement that no veins and no contact-metamorphism were found „in the sediments"; it is in the centralmassif itself, especially in the Palæozoic strata, Verrucano, all these things are found. It is of less consequence that metamorphism is found „in the sediments" too.

Another great mistake is the explanation of solid rocks folding as potters clay and the force necessary to do it. The plasticity, inherent in the mineral grain, could only be explained by deep profundity of rocks and consequently an immense overarching load of rocks was indispensable. As nothing of this immense

overload is found at present, it was necessary to get it removed again by later immense erosion, and so the geological periods must be of an immense length. The supposition of 9—10,000 years from the Glacial Period cannot serve as a standard for measurement of older periods, of course. Geologists speak of 1000—1500 millions of years, but 10—15 millions of years may perhaps be nearer the real truth. To this formidable length of geological periods served also the previously mentioned mistake of the measurement of strata's thickness and the supposed formation of valleys only by running water. I have no hesitation in pronouncing the plasticity of rocks, as here stated, to be a mere physical impossibility. The more hypothetical force, the tangential thrust, „das Horizontalschub”, produced by the shrinkage of the earth's crust, was in the folding acting from 2 opposite sides but in the overfolding only from one side, from south. The force in both cases must be so tremendous that it is a physical impossibility. Neither Heim nor any of his successors have even mentioned why this force was so local.

Another question is the cause of the unquestionable metamorphism found everywhere. It is but dynamo-metamorphism, and the cause is by Heim only pressure, thrust, without all heat and water; this is an impossibility. Schardt demands besides pressure also heat, and Schmidt even dissolving agents, water. I do not think any geologist will deny heat to be an indispensable factor in metamorphism and even dissolving agents. But Schardt or Schmidt do not tell what the cause of these two factors is, and I doubt that they are able to tell it.

About 20 years later Heims folding was discarded as unsatisfactory and overfolding, overthrust, became the only saving theory. The fundamental principle in this new theory is quite the same as in the old one: plasticity, now removed immense overarching load, immense erosion and immense geological periods. The difference is that the tangential thrust is only acting from one side, from south, and in a stupendous long time. The force must be stronger than in Heims folding, but what was the cause of this Quixotic force, why was it acting for such long times, and why was it so local? The overfolding-, overthrust-theory is built upon the famous overthrust in the Highlands of Scotland as its fundamental base. These two overthrusts have only

in common the name "overthrust", but in all other respects the are absolutely contradictory. In Scotland we have a real overthrust, but in the Alps a real overfolding, and these two quite different things have nothing in common. This principal base of the Alpine overfolding does not exist. In the Highlands of Scotland there is in fact a real unquestionable overthrust, produced in a quite natural way by eruption; the explanation will be given later on when I speak of the eruptive theory. In the Alpine overfoldings there is yet a multitude of questions to be answered but which cannot be answered. The Alpine overfolding is a physical and reasonable impossibility. Everybody who really will see must also see that it cannot be.

Heims theory is a romantic absurdity, but the modern one is belonging to a nursery-tale. Rothpletz is already fighting for overfolding from east and why not?

Is it really the intention to make geology a laughing-stock for all the world, and this in the 20th century? Is it not time to make an end to all this?

The eruptive theory solves all questions in a rational and natural way; if not so, it cannot be the truth. It is "Veritas" we have to make a search for at whatever cost.

The eruption has absolutely no use for immense overload, immense erosion and vast geological periods; of course a moderate erosion has existed since middle-Tertiary time. Nor are demanded any other extravagances as plasticity of the mineral grain, deep profundity of rocks, carving out of valleys by running water, immense thickness of strata etc.

The force, demanded for the work, must be very strong of course but not unimaginable. Besides, the force is divided in two different components, ergo smaller, the second force only a natural consequence of the first. The force was active for a short time and it found a weak place in the earths crust where to produce its effect.

The magma alone was fluid, but all other rocks were solid, broken asunder and curved, not at all folded or overfolded.

Gneiss is old archæan gneiss, wherever it is found. The expression "Archæan" is here used both to proper Archæan and

pré-Cambrian, Algonkian or proterozoic, in German "das Urgebirge".

Granite and its differentiations are always younger eruptives, post-Archæan. Of course a great part of these was older already consolidated rocks and uplifted in an solid condition when the eruption in Tertiary time produced the upheaval of the Alps.

In middle-Tertiary time shrinkage of the earths crust broke up, in a weak place, the solid crust into enormous flakes and larger or smaller fragments. The immediate sinking in drove out the magma, which found no place any longer in the diminished interior, through the openings and forced the magma upwards, carrying along with it the loose-broken parts of the crust and destroying more or less the uplifted overlying strata. Loose-broken rocks or whole strata from above sank down in the magma and was incorporated in it. Gneiss, Verrucano and even younger sediments were "swallowed up" by the magma. The younger strata were more or less fractured and curved, made flexible by heat transferred from the underlying magma. By this horrible disturbance is explained the colossal pell-mell entanglements of now visible rocks. The younger sediments, from Mesozoic time upwards, were thrown aside, uplifted, even disrupted and thrown down in yet younger sediments. In this last case you may call them "rootless". Gneiss or Verrucano were sometimes driven up through younger sediments to the summits of the mountains. Older strata are found lying higher than younger strata, but they are not in fact "overlying" the younger strata. It must never be forgotten that the sediments do not run through the mountains beneath higher lying strata as now supposed, but they are only a crust lying outside the inner rocks. The less consolidated youngest-Tertiary strata slid, perhaps mostly, down and were accumulated in the open less elevated places, the valleys, where the running water has only carved out its own bed.

The eruption in the Alps was never extrusive but always instrusive, i. e. the eruptive magma was everywhere protected by solid strata from flowing out and filling the valleys between the higher uplifted mountains and hills.

Since the upheaval of the Alps, not an exceedingly long time, some erosion has laid bare different rocks and yet remain-

ing rests, higher up or lower down. Every pré-Tertiary rock, eruptive or sedimentary, is lifted up in a solid condition not at all as a fluid magma. Valleys and Lowlands are but less uplifted regions.

A willing mind will easily carry to completion my present short sketch.

The famous much disused overthrust in the Highlands of Scotland affords a good example of my eruptive theory. Shrinkage has here broken up the crust in extensive flakes. A western flake sank down especially in the eastern part and an eastern flake was by the magma lifted more up in its western part. The shrinkage of the earth's crust pushed the two flakes in opposite directions, the uplifted eastern flake is pushed westward above the western flake which is pushed downwards to the east below the eastern flake. This real overthrust is no overfolding.

The key to the understanding of mountain-making is lying in the Norwegian plateau-mountains where there are only three different strata. Younger eruptive granite formed the mountains, above granite is lying uplifted phyllite, but in some places the gneiss-formation is pressed up from „das Urgebirge” and thrust into the overlying Palæozoic system which, now nearly quite removed from the surface of the gneiss-formation, is considered lying beneath the gneiss-formation. Our ingenious geologist Theodor Kjerulf had a perfectly correct view of the granite as being a younger eruptive, his „foot-granite”, which had „swallowed up” parts of the overlying uplifted phyllite, but unfortunately he could not manage the gneiss-formation and at last he went over to the view of Mr. Brøgger, who introduced into the Norwegian geology the absurdities of Heim and declared the gneiss-formation to be younger than the underlying phyllite and to be the uppermost stratum, at least partly sedimentary.

Concluding my treatise I must address the geologists in the words of Cicero:

„Quousque Tandem — !”
