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Artikel: The rôle of accretionary wedges in the growth of continents : asiatic examples from Argand to plate tectonics
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Argand thus noticed that the closure of major oceans produced accretionary complexes that added to continents. Fig. 7 shows the situation in the Mediterranean area after continental collision, in which Argand clearly distinguished suture *lines* from accretionary material-filled suture *zones*. These two styles of continental apposition were elaborated by different people following Argand's presentation.

4. Post-Argandian mobilism and continental growth before plate tectonics

The man who developed the ideas and the terminology about suture *lines* after Argand was Wilhelm Salomon-Calvi, one of the few outstanding field geologists of the early part of this century, who became convinced of the reality of continental drift:

> "If the assumption that continents drift towards one another and thus may come into contact is correct, then surfaces of apposition *(Zusammenschubflächen)* must form. *These will be similar to faults,* because along them masses come into contact with one another, which had not been in touch before. But they have a completely different character and a completely different meaning. That is why we use a special expression for them in what follows" (Salomon-Calvi 1930, p. 4, italics ours).

The special expression Salomon-Calvi invented was *Synaphie* (from the Greek συναφεια meaning union, unity of rythm, concordance) that may be anglicised as synaphia. He had also thought of *suture* (in German *Narbe),* but decided against it,

> "because a suture is a healed wound of a former injury, but synaphia is a welded juncture that brings together two masses that had not been one before" (Salomon-Calvi 1930, p. 20).

This distinction between a suture and a synaphia shows clearly how well Salomon-Calvi appreciated the implications of continental drift in terms of a tremendous continental mobility.

Salomon-Calvi considered synaphias as *lines* of apposition, although he pointed out in 1936 that such lines may be multi-branched encircling former "betwixt lands" *(Zwischenländer:* Salomon-Calvi 1936, p. 12; compare with Wegener's "microcontinent" depicted in Fig. 2). This "clean" conception of synaphias resulted from the fact that Salomon-Calvi developed his views on the examples of faults that formed following continental collision and that only partly followed the real suture zones (e.g. the Tonale line in the Alps, the North Anatolian fault in Turkey).

If dominance of folding in orogeny was a Swiss heritage through Escher and the father Heim, the dominance of thrust faulting was an Austrian conviction inherited mainly from von Richthofen's Vorarlberg work and Eduard Suess. Otto Ampferer realised very early that the enormous shortening seen in the sedimentary cover of the Alps could not have been parallelled by a similar shortening of the crust that underlay it, unless considerable portions of the crust had disappeared in a manner reminiscent of Holmquist's (1901) suggestion. This, Ampferer called *Verschluckung* in 1911 (Ampferer & Hammer 1911, p. 699 as *Verschluckungszone)* and depicted it in a schematic section in 1928 (Fig. 1E).

The essence of Ampferer's concept was that the entire process of orogenesis was really nothing more than movement along one immense thrust fault (e.g. AMPFERER 1928, p. 346) along which the cover of the underthrusting plate was scraped off and piled up in the form of a huge accretionary prism (Fig. 1E). In a subsequent figure (Fig. 1F), Ampferer showed how he thought that wedge would grow, in criticism of ARGAND's (1916, 1924) synchronously-moving embryonic folds.

How the accretionary masses Ampferer described are accommodated in a completed orogenic edifice and what they imply in terms of the palaeogeography of the orogen was discussed by another Austrian, namely Franz Eduard Suess, Eduard Suess' geologist son. In his incredibly perceptive, but regrettably diffuse writings, SUESS (1937, 1938, 1939) pointed out that most orogens consist of three main tectonic units: 1) A "producing slab" *(erzeugende Scholle)* is represented by the highest far-thrusted unit including evidence of past magmatic activity. This overlies 2) an "overridden zone" *(überfahrene Zone)*, composed of numerous metamorphosed thrust slices. 3) Finally an "unburdened foreland" *(unbelastete Zone)* contains offscraped continental margin and foredeep sedimentary rocks piled up in essentially unmetamorphosed nappes (Fig. 8). SUESS (1937, p. 11) pointed out that the metamorphosed sedimentary rocks of the "overridden zone" corresponded with an older foredeep in front of the magmatic "producing slab". Suess thus implied that the sedimentary rocks of the orogen that now lay under the "producing slab" represented a scraped off and accreted pile, emphasizing

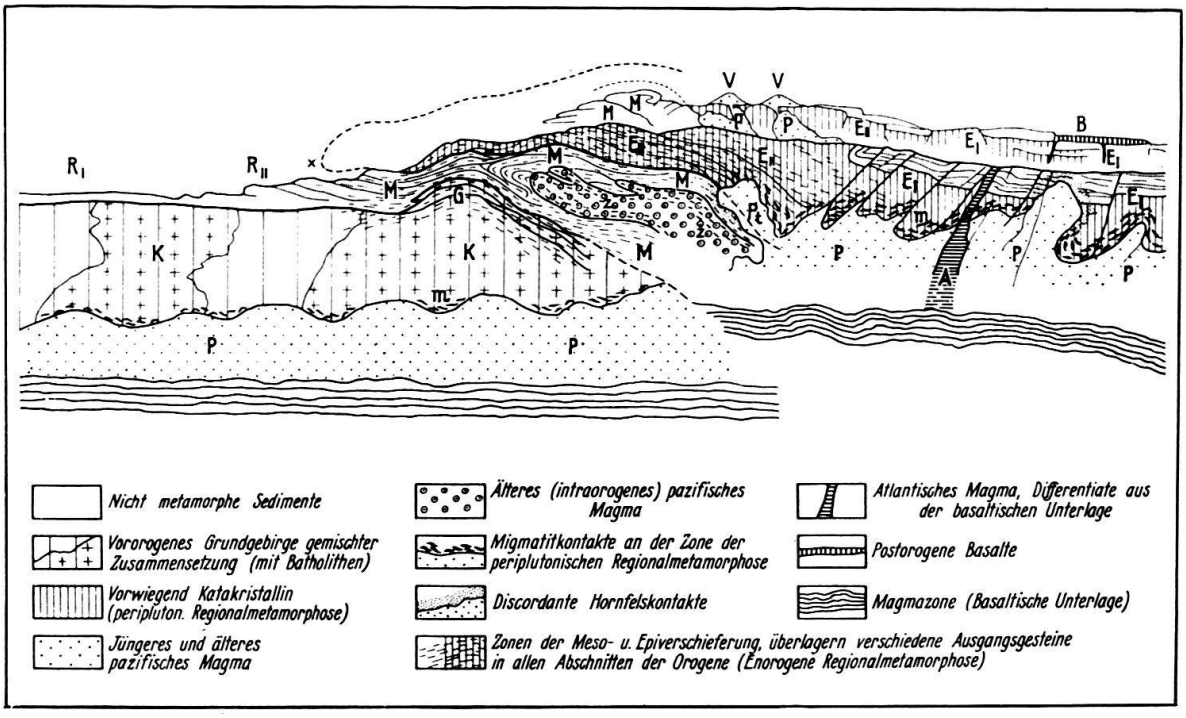

Fig. 8. Franz Eduard Suess' ideal collisional orogen. E. *Erzeugende Scholle* ("producing block"), with evidence for extensive former magmatic activity and with batholiths of "Pacific-type magma" (i.e. calc-alkalic), shown with P. V's are crestal volcanoes of calc-alkalic affinity. M – Metamorphic fold and thrust zone (the "overridden zone"). K – Crystalline basement of the foreland. The "overridden zone" corresponds largely with Argand's accretionary Penninic axial Tethys (SUESS 1937, fig. 1).

that "The characteristics of the orogen are most fully developed in the 'continental margin ranges'. Where they are juxtaposed against a foreign foreland, palaeogeography and tectonics indicate drift over large distances" (Suess 1937, p. VI).

Thus, before Argand died on 17th September, 1940, in the midst of an unprecedented world conflagration, not only the gross architecture of the accretionary terrains had been understood, but also some of the ideas concerning the aid they might render in studying the history of past oceans had been developed. Suture zones containing them were recognised to be an end-member in a spectrum, whose opposite end was formed by the clean suture lines, the synaphias of Salomon-Calvi.

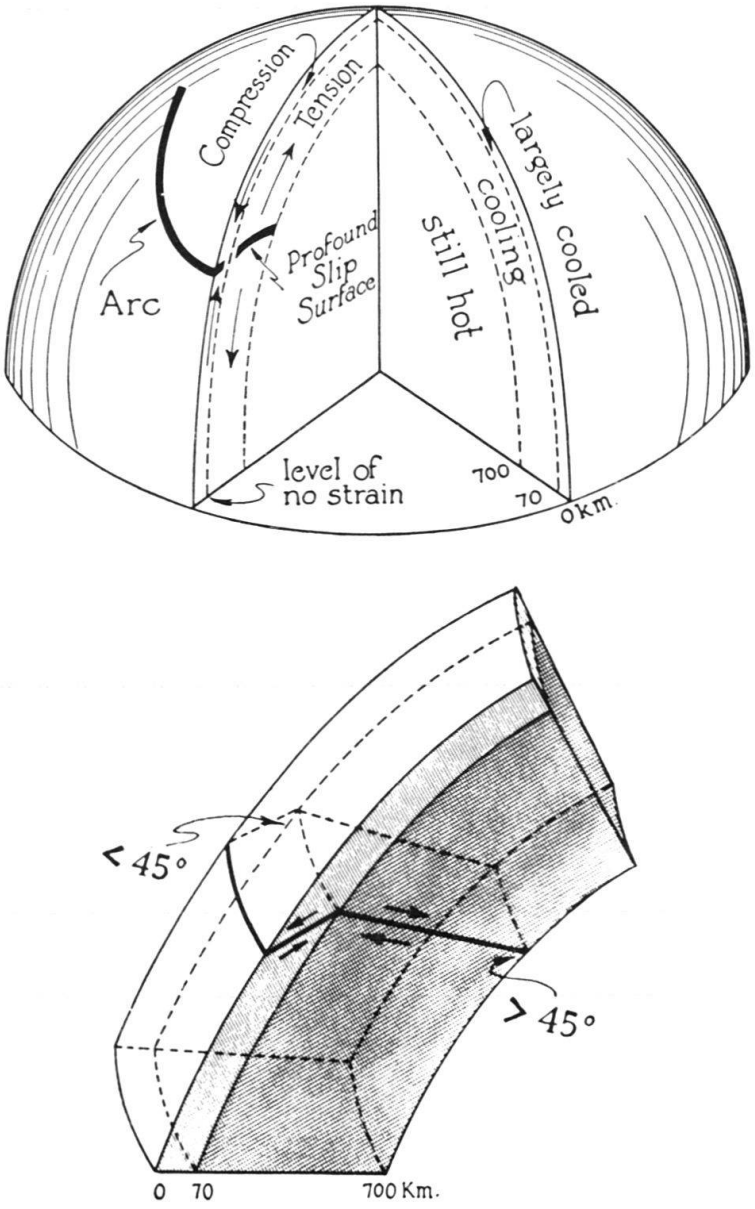

Fig. 9. Scheidegger's development of the contraction theory that Wilson (1954) used as a basis for his views on the consequences and causes of orogenic deformation. Compare this with Suess' description in Suess (1875, p. 146). Copied from Wilson (1954, fig. 13).

Franz Eduard Suess too passed away on 25th January, 1942, and, with Ampferer, retired in 1938 (he died in 1947), the mobilist movement lost its powerful leadership[13]). After World War II, the lead in global tectonics passed once more into the hands of the fixists both in Europe and in America, and most of the ideas I outlined so far were forgotten. When WILSON (1954) put forward his model of continental growth through orogeny, nearly three to two decades after the writings of Argand, Ampferer, Salomon-Calvi, and F.E. Suess had been published, the model of orogeny he used was still substantially the same as that employed by Eduard Suess in 1875! (Fig. 9).

The path of accretion tectonics trodden by Argand and his mobilist comrades had to be retravelled after the development of plate tectonics and the story we tell below of the tectonics of Asia may be interpreted as our not yet having reached the point on this particular path, where the magician of Neuchâtel and his companions might be awaiting our arrival.

In the second part of this paper, we describe some of the subduction-accretion-dominated Turkic-type orogenic belts of Central Asia (see Fig. 10) beginning with Argand's example of an accretionary – or Turkic-type in the sense here defined – orogenic belt, the Kuen-Lun, to document how Asia grew mainly during the Palaeozoic era and to contrast this with the Alpine and Himalayan type collisions of the Tethysides, in which continental enlargement took place mainly through continental collisions.

PART II

5. The palaeotectonic evolution of the Kuen-Lun/Songpan-Ganzi system

The Kuen-Lun is one of the most impressive mountain ranges of Asia, (Fig. 10) one that von RICHTHOFEN (1877, p. 223) designated as the "backbone of the eastern half of the continent". It was also on the example of the Kuen-Lun that one of the earliest theories of lateral continental accretion was proposed: "The Kuen-Lun thus appears to us as a sort of basement rooted into the oldest structure of the crust of the earth, a kind of pre-determined firm wall, onto which neighbouring areas were accreted through foldings of various orientations, until the whole formed a continent" (von RICHTHOFEN 1877, p. 225). As ŞENGÖR (1981, 1984) proposed and MOLNAR et al. (1987) and DEWEY at al. (1988a) corroborated, the Songpan-Ganzi accretionary complex (Fig. 10) largely forms a southerly appendage to the Kuen-Lun and represents an organic whole with it. As the Songpan-Ganzi System has been discussed in some detail elsewhere (ŞENGÖR 1984; ŞENGÖR & HSÜ 1984; KRÖNER & ŞENGÖR 1988; ŞENGÖR et al. 1988), we do not elaborate further on its geology below.

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[13]) Influential mobilist leaders in the southern hemisphere, such as A.L. Du Toit and L. King survived the war, but were mostly interested in the extensional aspects of continental drift and did not make any significant contribution to orogeny in terms of drift. Little wonder that when eventually a mobilist theory of orogeny arose from the southern hemisphere, it interpreted orogeny as an extensional phenomenon! (Cf. CAREY 1958; see also CAREY 1988, p. 89–119).