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Subduction

Subduction, a term introduced by André Amstutz (1951, p. 326), is the abrupt descent of a segment of lithosphere. It commonly involves convergence and underthrusting of adjacent lithospheric plates but may involve downfolding within a single plate. A *subduction zone* is an abruptly descending or formerly descended elongate body of lithosphere, together with any existing envelope of inter-plate deformation. We advocate use of the term *subduction* because of its general applicability to plate tectonics past and present, its explicit origin and historical development, its suitability in several languages, its freedom (as defined above) from genetic implications, and its independence of possibly unwarranted inferences about associated seismic, topographic, or bathymetric features. We also advocate its use in preference to a host of other terms proposed in the literature.

Amstutz not only introduced the word *subduction* but also used his knowledge of Alpine structure to develop concepts that are in remarkable accord with current theories of plate tectonics. Acknowledging the influence of A. Rittmann's ideas, Amstutz postulated (1952a, p. 1896) that descending convection currents created the Alpine geosyncline and pulled adhering crustal material down obliquely beneath the foreland. He recognized (1952b, p. 2095) that subduction causes stretching in the block below the main shear surface, and folding and imbricate thrusting in the block above. He regarded subsequent gravity sliding into resulting depressions or trenches to be an indirect or auxiliary result of subduction. (*See also* Amstutz, 1957, p. 2531, and 1962, p. 13–14.)

From observations in the Penninic Alps, Amstutz concluded (1954, p. 416–417) that the dip direction of initial subduction was reversed in a later phase, during which successive and parallel subduction zones were displaced progressively closer to the foreland. He thus developed the two separate concepts of flipping and of shifting subduction zones, and later amplified these ideas (Amstutz, 1965, p. 1559, and 1966, p. 1414). He (1954, p. 418) also was among those who recognized that the dipping zones (now called Benioff zones or Wadati zones) of earthquake hypocenters around the Pacific are associated with present-day subduction zones. His 1955 paper (p. 969) includes a set of three cross sections, reproduced here as Figure 1, illustrating the evolution of a subduction zone.

Sharpening of most geologic ideas follows the probings of forerunners; beginnings of a subduction concept can be traced at least as far back as Otto Ampferer's early work. Ampferer (1906, p. 603) assumed that thermally driven, down-welling mantle convection currents (*Unterströmungen*) were the causes of orogenic folding and shearing. Ampferer and Hammer (1911, p. 699) introduced the term *Verschluckungs-Zone* (literally, *swallowing-up zone*) and stated: "If a low-angle glide plane extended through the upper part of the crust, and if . . . the upper block . . . moved very extensively over the

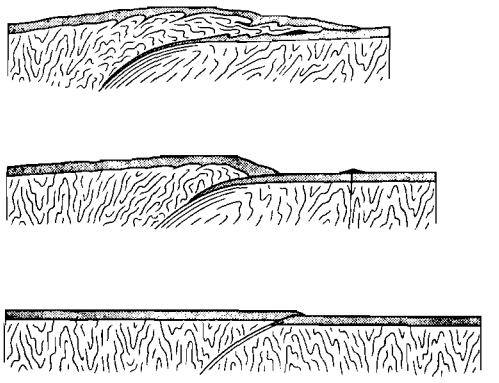

Figure 1. Reproduction of drawing *by* Amstutz (1955, p. 969), showing three stages of subduction.

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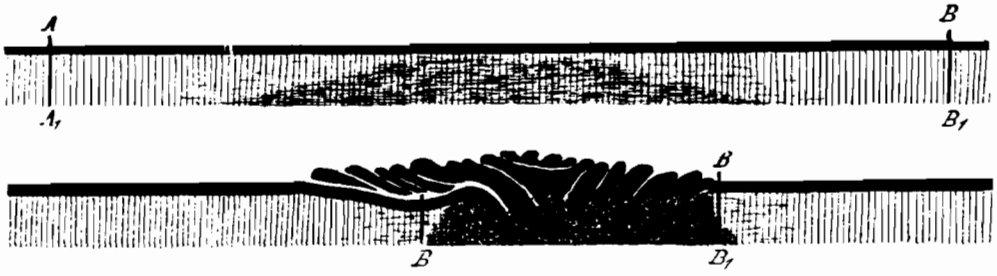

Figure 2. Reproduction of Figure 44 *of* Ampferer and Hammer (1911, p. 700), showing downsucking and thrusting of crust in a Verschluckungs-Zone (cross-hatched).

lower block, then it is possible that . . . enormous absorption of masses took place at depth and swallowed large parts of the upper crust." The only changes we would suggest today are to say "subduced" instead of "swallowed," and "lithosphere" instead of "upper crust." Figure 44 of Ampferer and Hammer (1911, p. 700) is reproduced here as Figure 2.

The utility of the term *subduction* was recognized by Gignoux (1953, p. 195), Rittman (1962, p. 254, a reference which also contains early ideas on sea-floor spreading), and many participants of the second Penrose Conference of The Geological Society of America (Dickinson, 1970a, p. 19, and 1970b, p. 1253). The term seems much more apt and explicit than such proposals of other authors as underthrust, down-going slab, overriding or overlapping plate, zone of convergence or shortening or destruction of crust, consumption zone, sink, trench, Benioff zone, Benioff-zone trench, island arc or arc-like structure where surficial materials descend, down-dragged crust, downwelling site, descending limb, take-up zone, undercurrent, or underflow. Use of the term *subduction* is not directly dependent on inferences about trenches, arcs, or inclined seismic zones; hence, this term is applicable to ancient deformed zones of lithosphere as well as to presently deforming ones.

We are indebted to Rudolf Trümpy for directing us to Amstutz' work, and to Esso Production Research Company for permission to publish.

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