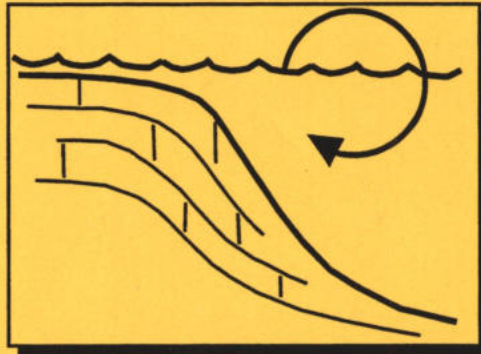


SEPM/IAS Research Conference



**CARBONATES AND GLOBAL CHANGE:  
AN INTERDISCIPLINARY APPROACH**

**FIELD TRIP TO THE CHURFIRSTEN:  
WILDHAUS-CHÄSERUGG**

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## WILDHAUS AND THE TOGGENBURG

The upper part of the *Toggenburg* valley with its villages *Unterwasser* and *Wildhaus* is flanked by the impressive *Alpstein-Mountains* with the highest peak, the *Säntis* (2504m) north of *Wildhaus* and by the *Churfürsten* chain in the south.

First traces of humans living in the *Toggenburg* region reach back into the last glacial. Neanderthal populations lived in caves along the *Churfürsten* around 40 000 BP. The cave *Wildmannlisloch* is located at an altitude of 1628m, an altitude which allowed life along the *Churfürsten* also during times of advanced glaciers. The cave *Wildmannlisloch* ("wild man's hole") was detected around 300 years ago and was first described by Scheuchzer in his *Natural History of Switzerland* (1716).

Farming activity in the *Toggenburg* region can be dated back into the 2nd century, but it took another 500 years until Alemannic people from the north began to move into the *Toggenburg* region. The land was divided up between aristocratic families. One of the most important of these families, the *von Toggenburg* family owned large parts of the region around the turn of the millennium. It is this family which gave the name to the region. Until the year 1400 the *Toggenburg* population was structured in a classical medieval way and agriculture was the most important economic activity. After the death of the last count, Friedrich II von *Toggenburg* in the year 1436, the *Toggenburg* was sold to the monastery of St. Gallen.

*Toggenburg* played a central role for the Swiss reformation movement in the early part of the 16th century. The two most influential Swiss reformers were Calvin and Zwingli.

Huldrych Zwingli was born in *Wildhaus* and he became the leader of the reformation movement in the region. The Catholics of the *Bischof Konstanz* and the monastery St. Gallen tried to fight this new movement. Heavy religious battles were the consequence not only in the *Toggenburg* region. Zwingli lost his life in one of the battles between Protestant and Catholics in the year 1531. In Calvinistic Geneva and in the Zwingli town *Zürich* we can still feel the very puritanic attitude of Zwingli and Calvin towards life. This helped the Swiss to become very successful in economic life but less successful in the arts...

The *Toggenburg* region was, after the defeat of the Protestants, partly recatholicized. While the upper part of the *Toggenburg* remained Protestant, the lower *Toggenburg* became Catholic again. Repeated political conflicts were a consequence of the differences in religion. Despite of these conflicts, the *Toggenburg* experienced a very positive economic development in the 17th and 18th century. The weaving industry, which later became the most important industry for the region, started around 1730 with the first home work factories. Agriculture was changed, when the potato was introduced into the *Toggenburg* in the year 1745. The activities of the population promoted the region to an export region for agricultural and industrial products. Extreme wet and cold years (1815-1817) had a dramatic impact upon the agriculture of the *Toggenburg* and people were forced to move to the *Rhein* valley in the hope to find enough food for survival. The large economic problems forced many *Toggenburgers* to work as mercenaries for foreign troops. Communities found their ways to get rid of persons which they considered as "lazy and difficult". These persons were forced by the communities to emigrate. Between 1845-1847, 42 persons from the *Wildhaus* region emigrated to North and South America.

The opening of the railway between *Wil* and *Ebnat* in the year 1870 opened the door to modern industrialisation and tourism. The first travel guide for the *Toggenburg* was

published in 1877 and first advertisements for tourism in the Toggenburg go back to the year 1892. Winter tourism started around 1904 and the first ski school was opened in 1906. The Iltios train was built 1934 and, after the second world war, winter tourism developed into the most important economic factor for the upper part of the Toggenburg.



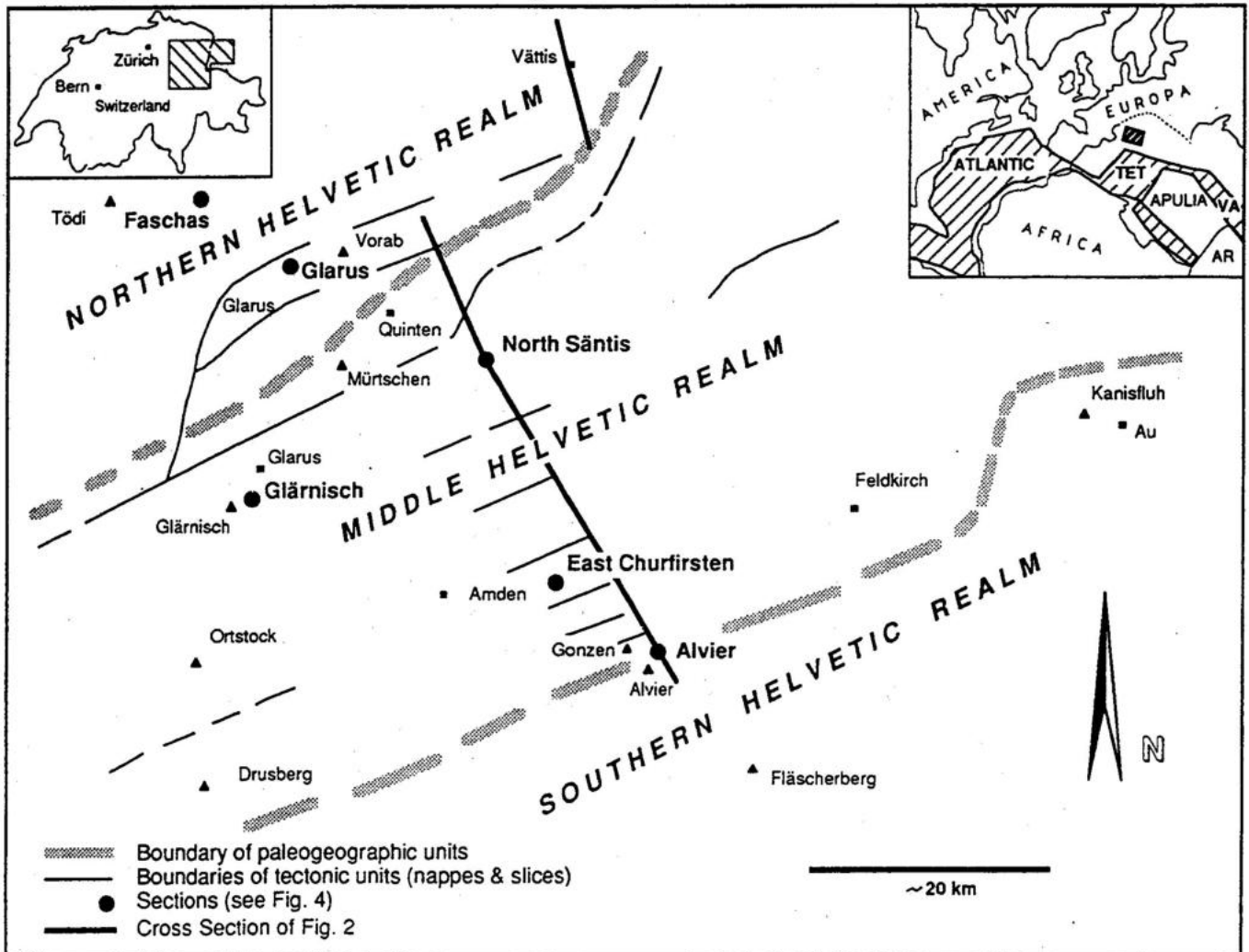
# The Geology of the Churfirsten

## 1) The northern margin of the alpine Tethys

First investigations of the Toggenburg regions were made by a local priest in the year 1770. A few years later the Säntis peak was conquered for the first time. In the 19th century the region was investigated by cartographers and by naturalists. Albert Heim, the great Swiss geologist, drew the first geological panorama of the Säntis. Arnold Heim, the son of Albert Heim published an impressive monography of the Churfirsten between 1910 and 1921.

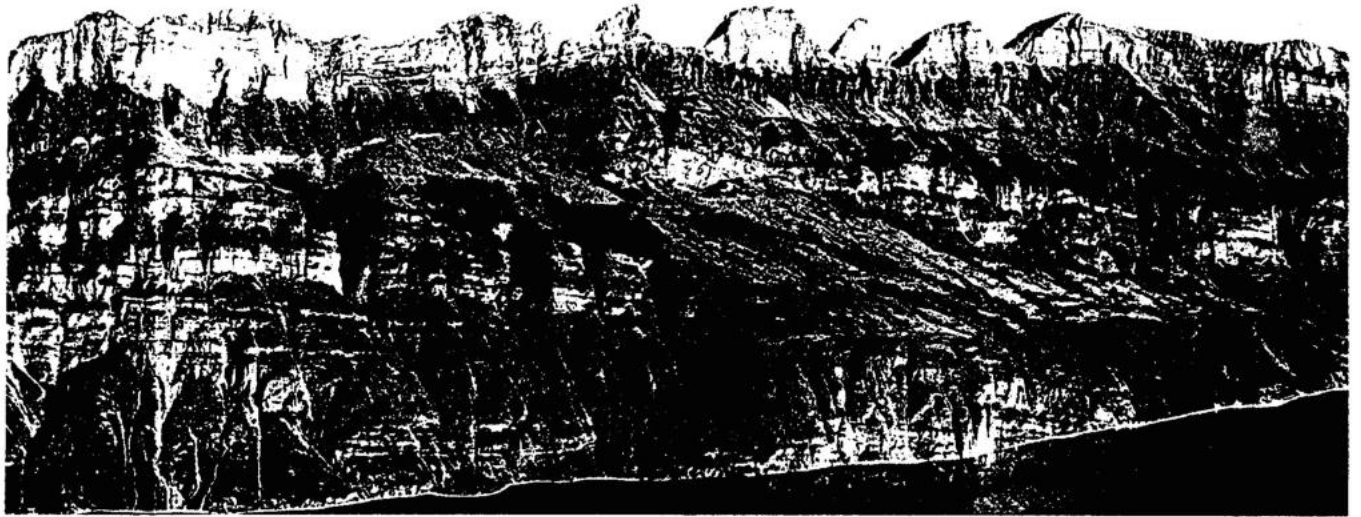
The Churfirsten and Säntis mountains form part of the northern Alps of Eastern Switzerland. Sedimentary rocks of Late Paleozoic to Tertiary age, stacked in a pile of nappes, form the *Helvetic* tectonic complex. These tectonic units can be grouped into (1) a lower, autochthonous and paraautochthonous unit which consists of folded and partly thrust sedimentary rocks and (2) an overlying allochthonous unit consisting of large nappe systems and smaller slices ("*Helvetic nappes*").

Figure 1: The Helvetic shelf during the Early Cretaceous (Funk et al., 1993).

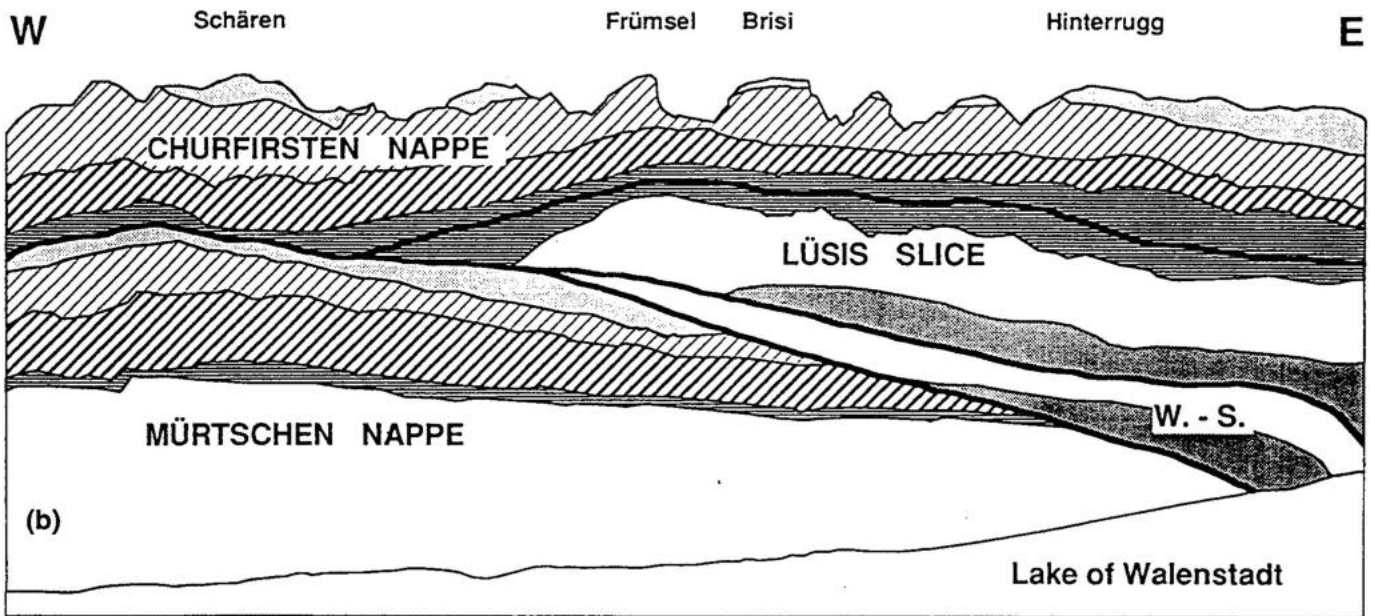


Palinspastic reconstruction of the Helvetic shelf in eastern Switzerland. Relative positions of unfolded nappes are indicated. Inset, upper left: map of Switzerland showing study area. Inset, upper right: paleogeographic map of Early Cretaceous time; hatched area is oceanic crust; TET = Tethys Ocean, VA = Vardar Ocean, AR = Arab Peninsula. (Inset after Bernoulli, 1981.)

Figure 2: Two cross sections through the Säntis - Churfiristen mountains (Heim, 1905, Funk et al., 1993).



(a)

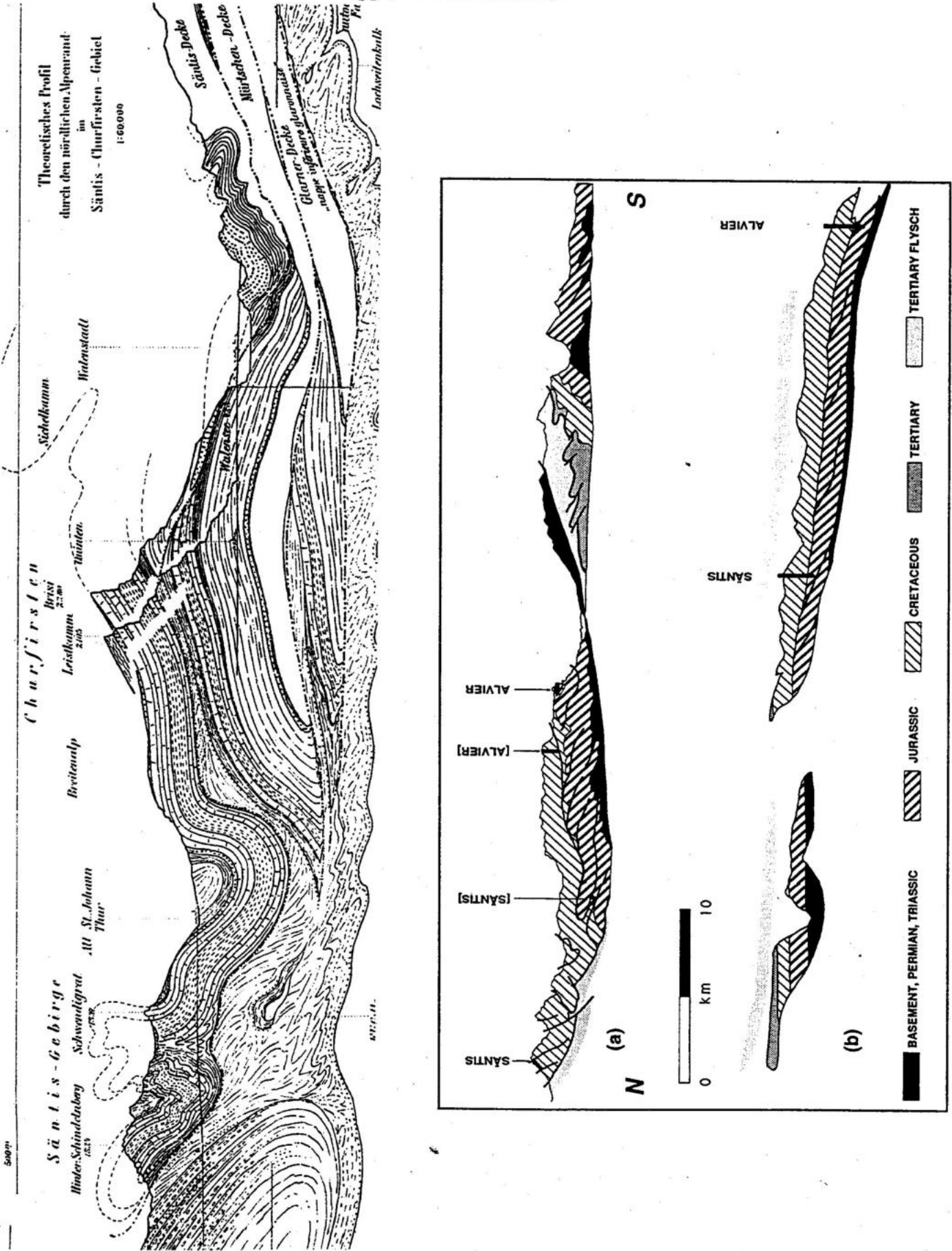


(b)



(a) The western Churfiristen north of the Lake of Walenstadt, view from the south. (Photograph from Heim, 1910.) (b) Tectonic interpretation of the Churfiristen area. In the Mürtschen nappe, platform limestones are observed in the Öhrli Formation (Berriasian-Valanginian) as well as in the Schrattekalk Formation (Barremian-Aptian). In the Churfiristen nappe, only the Schrattekalk Formation is of platform origin.

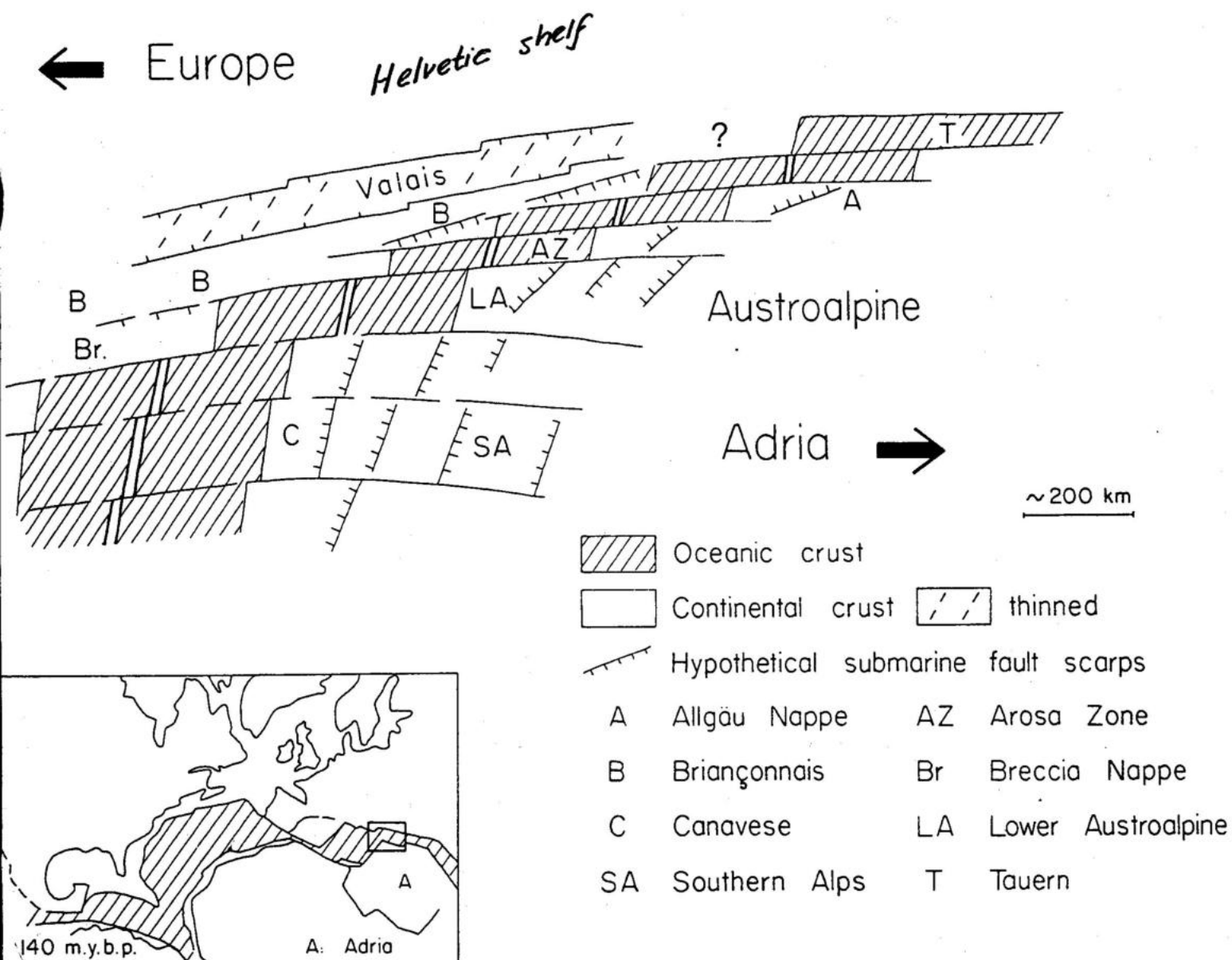
Figure 3: A view of the Churfürsten from the Walensee in the South. The Chäserugg is located east of the Hinterrugg (Funk et al., 1993).



(a) Cross section showing tectonic units and stratigraphy between the Sänktis mountains and the Rhine valley.  
 (b) Palinspastically restored cross section of the same area.

The sediments of the Helvetic thrust sheets were deposited along a zone which was located along the northern Tethyan margin after the opening of the alpine Tethys Ocean. The opening of this part of the Tethys Ocean occurred during the middle Jurassic. The opening history is documented in alpine ophiolite nappes separating today the northern Tethyan tectonic elements from the tectonic units which were derived from the Jurassic-Cretaceous southern margin of the alpine Tethys.

Figure 4: The Alpine Tethys during the Late Jurassic-Early Cretaceous (Weissert & Bernoulli, 1985).



### Säntis-Churfirsten nappe

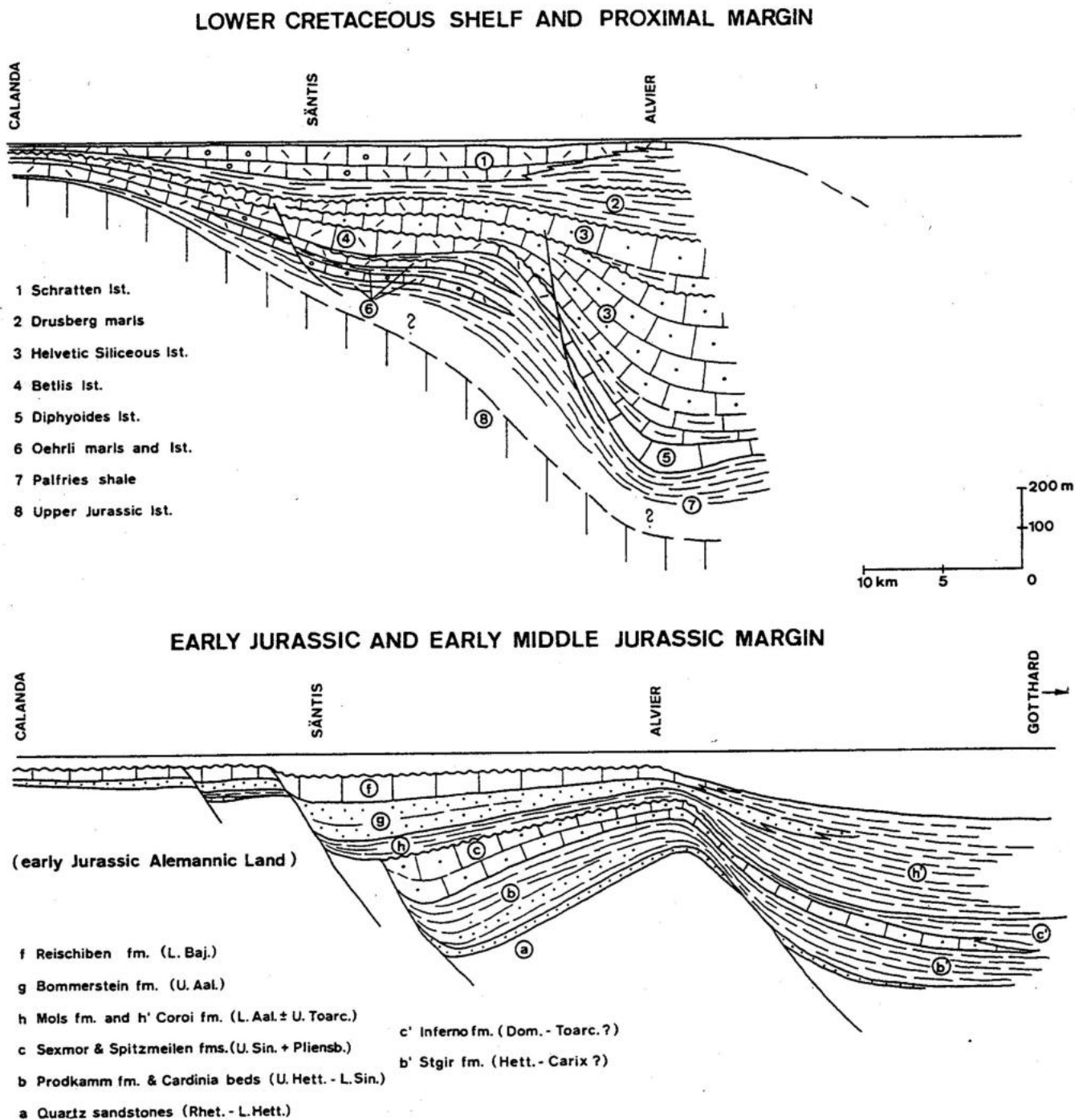
The Säntis-Churfirsten nappe is built up of limestones and marls of Cretaceous age. In a palinspastic reconstruction for the Early Cretaceous, the Säntis-Churfirsten region falls into an intermediate realm of the shelf plateau flanking the alpine Tethys Ocean. This margin can be traced towards the west into southern France and towards the east into the Carpathians. Its minimum length was about 1500km and its width about 100km.

During the Late Jurassic, Northern Tethyan reefs were prograding towards the south (Troskalk Formation). The southern limit of the prograding reefs marks the boundary between the northern and the intermediate Helvetic shelf region. Fine grained, dark pelagic limestones of the Quinten Formation were deposited south of these reefs. These pelagic limestones are of mid-Oxfordian to Tithonian age and they formed the base of the Cretaceous sediments outcropping today in the Säntis-Churfirsten region.

During the Early Cretaceous, relatively large crustal subsidence rates related to transtensional tectonics affected the northern Tethyan margin. These subsidence rates facilitated the accumulation of thick carbonate sequences along the broad and uniform shelf plateau. The carbonate platforms lacked fringing reefs and steep distal ramps. During times of sea level highstands the platforms could rapidly prograde over tens of kilometers.

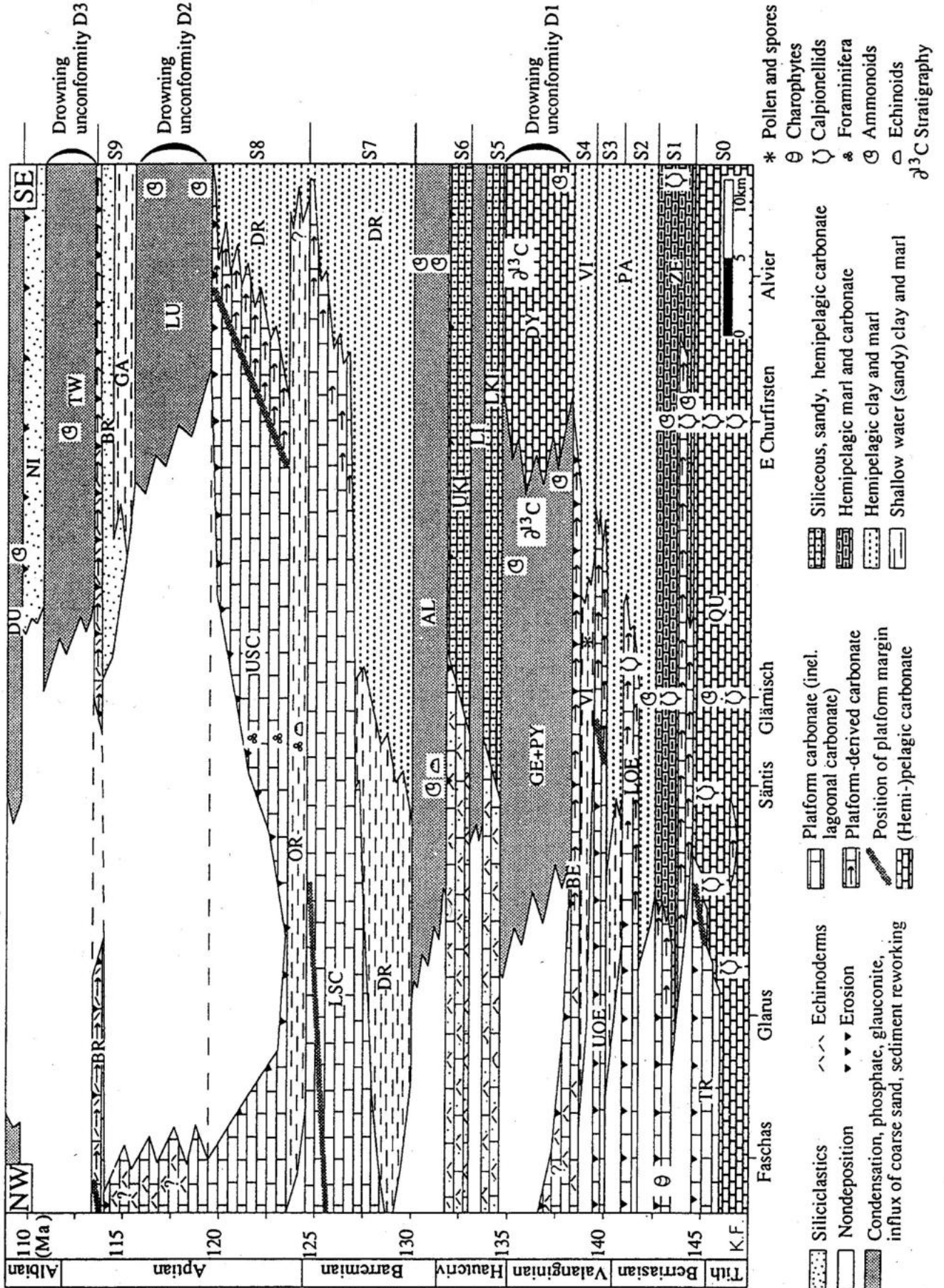
Platform development in the Early Cretaceous was not only influenced by sea level variations. Fluctuating nutrient concentrations resulted in repeated platform growth crises. The Cretaceous sequences reflect three modes of platform development: (1) an oligotrophic mode where hermatypic organisms and oolitic shoals could develop. (2) a mesotrophic mode, where sponges, crinoids, oysters, and bryozoan biostromes could develop and replace corals. (3) an eutrophic mode, resulting in repeated platform drowning and in the development of widespread phosphorite hardgrounds. Oligotrophic platform growth occurred during the Tithonian-Early Valanginian and the Barremian. These platform growth phases were regulated by sea level. Transitions to mesotrophic platform growth occurred during the mid-Valanginian and the Early Aptian. Increasing eutrophication caused drowning of the Northern Tethyan platforms during the Late Valanginian - Early Hauterivian, during the Late Hauterivian, and during the Aptian. Drowning episodes were interrupted by intervals of renewed progradation of crinoid dominated carbonate platforms, e.g. in the Hauterivian and in the mid-Aptian.

Figure 5: A section through the Jurassic-Cretaceous Helvetic shelf (Trümpy, 1980).



Palinspastic sections through the Helvetic continental margin in eastern Switzerland. Upper section by H. Funk.  
*Coupes palinspastiques à travers la marge continentale helvétique en Suisse orientale. Coupe supérieure par H. Funk.*

Figure 6: Time-space diagram of Late Jurassic-Early Cretaceous units in the eastern Helvetic area (Funk et al., 1993).



Time-space diagram of the units of late Tithonian-early Albian age in the eastern Helvetic area. Stratigraphic sequences are indicated on the right.

Figure 7: Time-space diagram of a drowning unconformity (Föllmi et al., 1994).

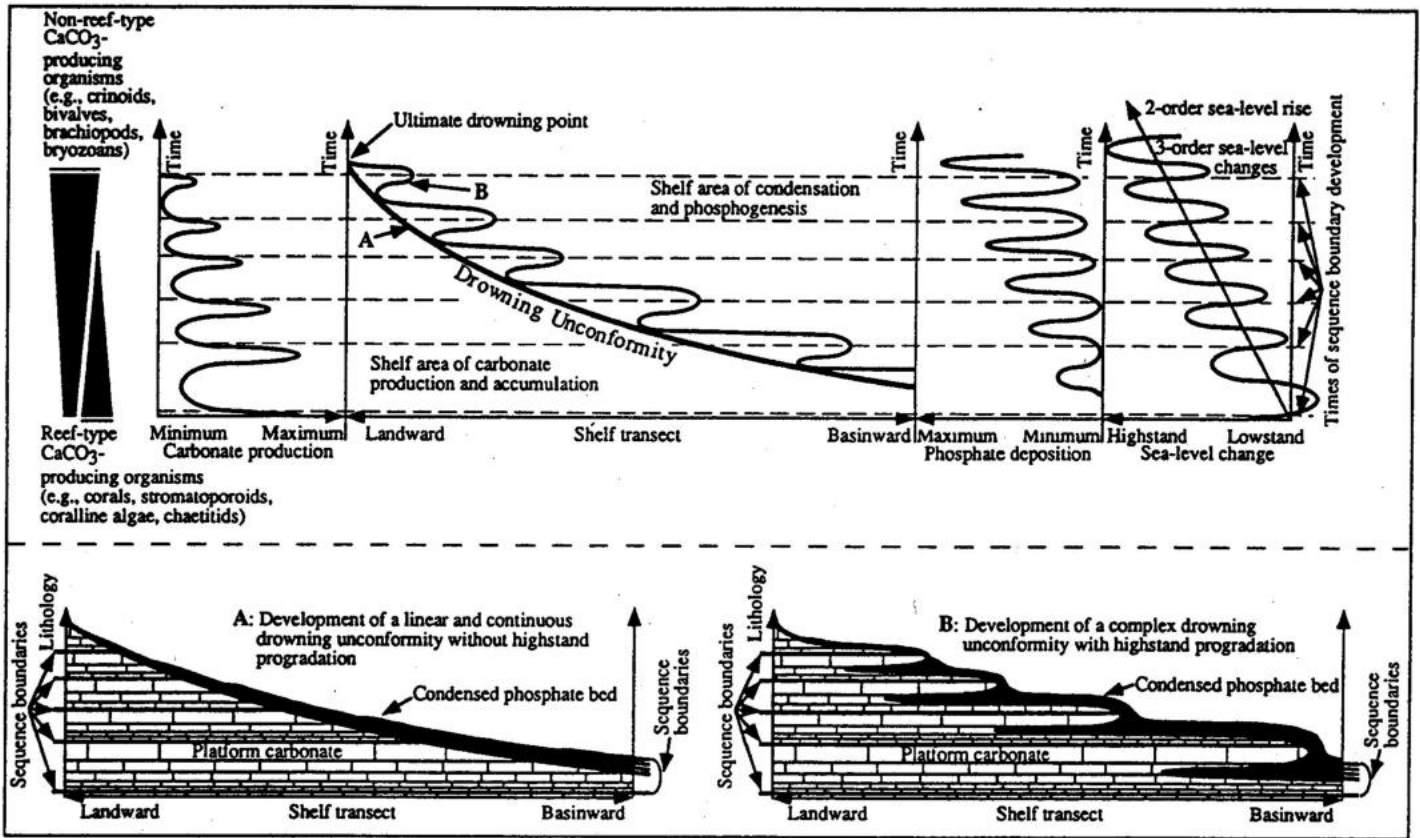
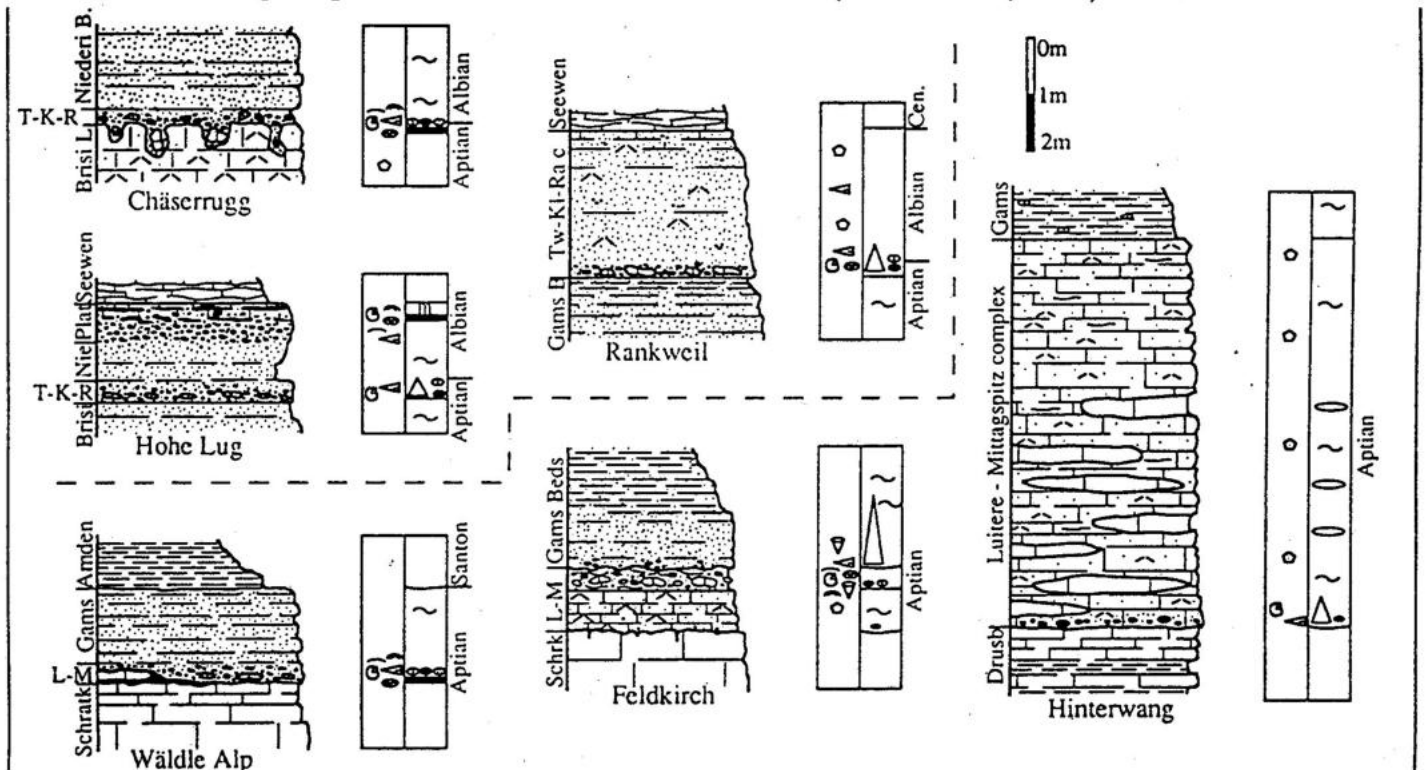
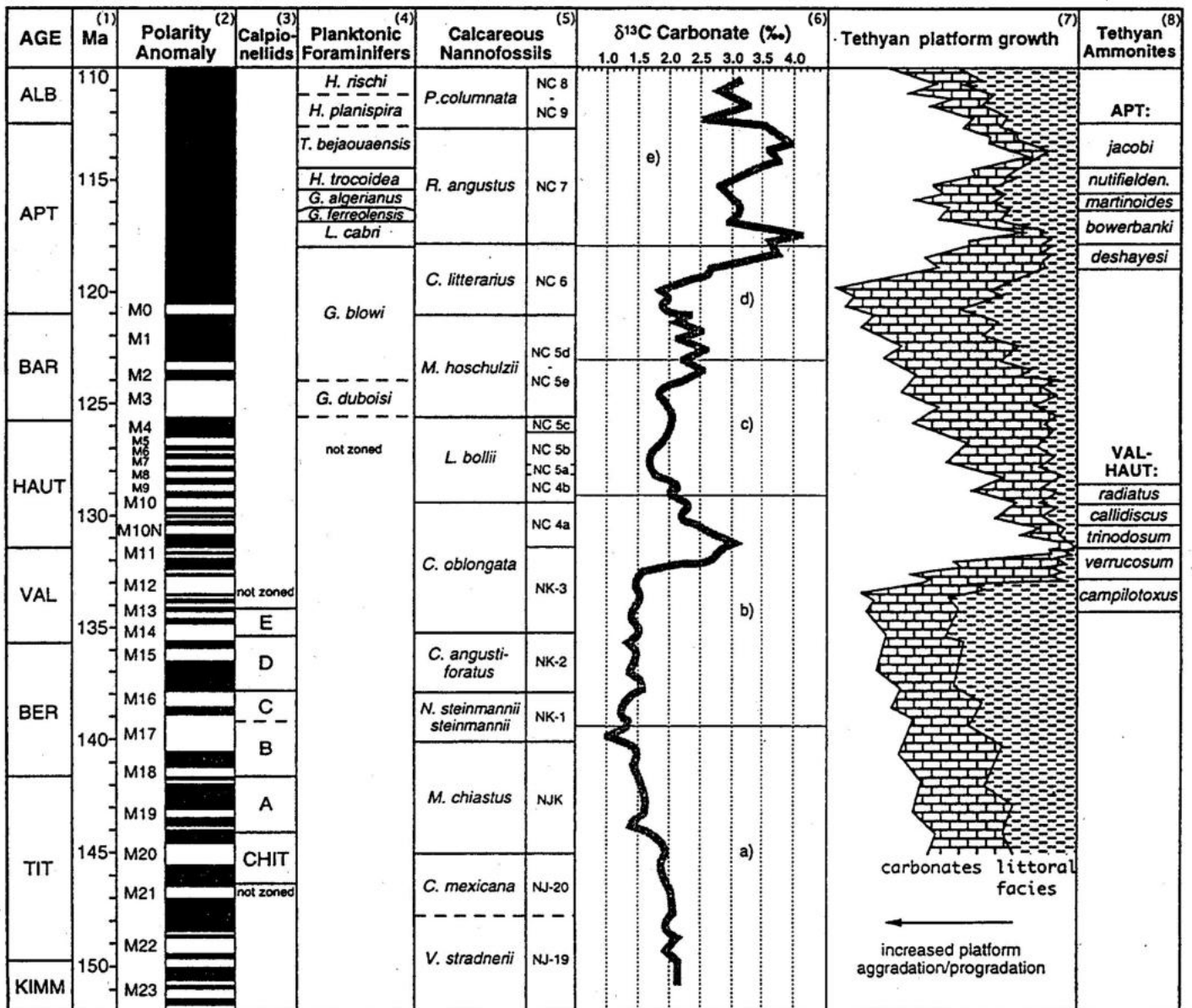


Figure 8: A selection of Aptian sections in the Helvetic Alps of eastern Switzerland showing the transition from a carbonate platform to a condensed interval rich in glauconite, phosphate and mature siliciclastic sand (Föllmi et al., 1994).



The two major carbonate platform drowning episodes of the Valanginian and of the Aptian coincide with major perturbations of the global carbon cycle as indicated by positive excursions in the C-isotope stratigraphy. The coincidence of C-isotope excursions, black shale deposits in the deep sea and platform drowning along river - influenced coasts shows contrasting response of the marine organic and the carbonate carbon pumps to episodes of eutrophication .

Figure 9: Early Cretaceous C-isotope stratigraphy and evolution of northern Tethyan carbonate platforms (Weissert, Lini & Föllmi, unpublished)



## 2. The Aptian platform drowning and the deepening of the Helvetic shelf: a record from the Chäserugg

### Stratigraphy:

#### -Schrattenkalk-Formation (Barremian- Early Aptian):

The Schrattenkalk-Formation is of Barremian-Early Aptian age and it can be grouped into three subunits:

The Lower Schrattenkalk (LSK) has a thickness of around 100m. Thick bedded bioclastic limestones alternate with an upward increasing number of oolite beds. Crinoids form up to 30% of the carbonate clasts in the lower part of the subunit. The content of clay and silt-sized siliciclastics (clay, quartz:fsp=3:1) is decreasing towards the top of the subunit. The LSK was formed on an open platform under dominantly high energy and increasingly clearer water conditions. Rudists are less common than in the Upper Schrattenkalk.

The middle Schrattenkalk, elsewhere described as Orbitolina Beds (OR), is built up of up to 30m of thin bedded silty and marly bioclastic limestones and marls enriched in quartz and clay. In addition to a rich Orbitolina fauna the OR contains corals, mollusks and miliolids. Thin clay seams or marl horizons are interbedded between the limestone layers. The MSK was formed in a muddy or even sandy shallow water environment. In other regions paleosoils and emersions surfaces are included in the Orbitolina Beds.

The upper Schrattenkalk varies in thickness between 30 and 90 m. It consists of bioclastic and peloidal limestones and marlstones including corals, stromatoporoids and up to 20% crinoidal debris. Two horizons enriched in orbitolids have been recognized in the USK, one just above the OR and a second one in the upper half of the unit. Towards the top of the formation the bioclastic limestone is replaced by a quartzose limestone including silicified oyster debris and crinoids. Three glauconitic marls in the upper part of the USK can be recognized throughout the Säntis-Churfirsten nappe. The siliciclastic debris is very mature with a Qz:Fsp ratio of 15:1.

#### -Garschella-Formation:

The top of the Schrattenkalk is coated by a phosphatic crust and a thin nodular phosphatic bed called Luitere Bed. Deposition of the Luitere Bed began in the Early Aptian (Deshayites deshayesi ammonite zone). This phosphorite bed is interpreted as a drowning unconformity, formed under increasingly open marine conditions. Strong currents and increased nutrient levels formed an environment which was hostile for carbonate platform growth.

The Luitere Bed is overlain by up to 50 m of dark-coloured and fine-grained glauconite-bearing marls, described as Gams Beds. These marls are overlain by a coarse-grained quartzose and glauconitic bioclastic sandstone rich in crinoids, bryozoans, bivalves (including oysters levels) and brachiopods (Brisi Beds). The siliciclastic particles are dominated by quartz (Qz: Fsp: Glauconite =45:1:15). The sequence Gams Beds-Brisi sandstone is characterized by a distinct coarsening upward trend in the siliciclastic fraction and a concomitant decrease in the clay fraction. The sequence is interpreted as a high stand deposit and the source of the



