Young Researchers in Structural Geology and Tectonics

YORSGET 2018 *Montgenèvre: 1st - 6th July*

Programme
and field guide

Welcome to Montgenèvre and YORSGET 2018, the conference for Young Researchers in Structural Geology and Tectonics.

This booklet contains the scientific programme, the delegate list and the guide for the conference field excursions. For conference participants the abstract are on the conference USB pen drive, together with a digital version of this guide. Otherwise all documents are available at the conference website.

We thank the science committee for helping us put this all together, the keynote speakers and session chairs and our sponsors: TecTask, TSG, the Cottian Alps Geopark and our universities. We especially thank the community of Montgenèvre for hosting YORSGET 2018.
And we hope you enjoy the unique geological and cultural delights of the French Alps.

Welcome!

Taija Torvela (on behalf of the YORSGET team)

Summary timetable

Sunday 1st July

18.00-19.30	Icebreaker reception (Graal Cafe)

Monday 2nd July

08.45	Doors open: late registrations and poster set-up.
09:15	Welcome and introduction
09.30	Oral presentations begin (posters in breaks)

including briefing for field excursions, by Rob Butler (at 15.15)

15.45-17.30	Posters and afternoon reception

Tuesday 3rd July

08:15	Field excursion to La Grave and Galibier
	Depart from Graal Cafe (Route d'Italie)
19:00	Return to Montgenevre

Wednesday 4th July

09.30	Oral presentations begin (posters in breaks)
	Includes introduction to rifted continental margins (group activity)
15.45-17.30	Posters and afternoon reception

Thursday 5th July

09.20	Field Excursion to Le Chenaillet.
	Meet at Chalmettes chair lift station. Full day out in the hills.
17:00	Return to Montgenevre (or later if walk extended).

Friday 6th July

09.30	Oral presentations begin
	Includes discussion and reflections on field excursions
17.00	CLOSE
19.15	Conference dinner at Graal Cafe.

Logistics

Conference held in Cinema Jean Gabin (Rue des Ecoles)
Doors open at 08.45 on Monday.

Posters
Hang from 8.45 on Monday. Remove at 17.30 on Wednesday

Oral presentations.
Please upload your powerpoint presentations by the start of the break before your session.
All presentations will be deleted at the end of the conference.

Posters

Billy Andrews, Z. Cumberpatch, Z. Shipton, R. Lord
The importance of stratigraphy and sedimentary structures in fault and fracture development in fluvio-deltaic sequences

Luigi Berio, F. Balsamo, S. Mittempergher, M. Mozafari, M. Meda, F. Storti
Deformation pattern in the thrust-related Parmelan Anticline (Bornes Massif, Subalpine Chains, Haute-Savoie, France): preliminary results

Rob Butler, T. Torvela
The pegmatite paradox: competing rates of deformation and crystallization

Norbert Caldera, A. Teixell, A. Griera, P. Labaume, X. Coll, N. Mestres
On the tectonic structures of the Eaux-Chaudes massif (western Pyrenees): a Helvetic nappe type in the Pyrenees?

Adam J. Cawood, C. Bond
eRock: on online, open-access repository of virtual outcrops in 3D

Anna Chanou, M. I. de Paz-Álvarez, H. Lebit, R. Carosi
Outcropedia, a public database of all important and beautiful outcrops in the World

Fabrizio Cocco, A. Funedda, C. Buttau, S. Naitza
Late Variscan ore deposits in the Baccu Locci shear zone (SE Sardinia): a field example of structurally controlled mineralizations

Alberto Corno, M. Gattiglio, A. Borghi, P. Mosca
Lithostratigraphic, structural and petrographic features of the Monte Banchetta – Punta Rognosa area (Western Alps, Italy)

Sophie Cox; Å. Fagereng; C. MacLeod
Geometry, Deformation Mechanisms and Seismic Style of Oceanic Transform Faults

Manuel Ignacio de Paz-Álvarez, J. L. Alonso, S. Llana-Fúnez
The Esla Nappe (Cantabrian Zone, NW Iberia): preliminary data on its basal shear zone damage and fault rock assemblages

Jordy de Vries
The Pyrenean Variscan Mérens intrusion: mineralogy, timing and strain partitioning within a mylonitised root zone

Sian L. Evans, C. A.-L. Jackson
Intrasalt structure and strain partitioning in layered evaporites: insights from the Messinian salt in the eastern Mediterranean

Lorenzo Gemignani, D. Peacock, M. Jessell, R. Carosi
TecTask "OpenTerminology", a public debate regarding geological terminology for Geoscientists

Tong Hong, S. Lin, C. van Staal, W. Ji
Final closure of the Paleo-Asian Ocean and terminal collision in the Central Asian Orogenic Belt: Constraints from the Beishan Orogenic Collage, Northwest China

Salvatore Iaccarino, R. Carosi, C. Montomoli, M. Simonetti, M. Lezzerini
The hinterland-foreland transition in the Variscan belt of Sardinia (Italy): insights from the Barbagia Thrust

Shelby Johnston
Combined 40Ar/39Ar and 87Sr/86Sr analyses of modern muscovites in the Narayani River catchment, Central Nepal

Harold Leah, M. Fondriest, A. Lucca, F. Storti, F. Balsamo, G. di Toro
Coseismic extension recorded within the damage zone of the Vado di Ferruccio Thrust Fault, Central Apennines, Italy

Cyril Lobjoie, P. Trap, E. Oliot, W. Lin , P. Goncalves, D. Marquer
Structural and microstructural study of the ultra-high temperature Khondalite Belt, North China Craton

Flora Feitosa Menezes, C. Lempp
Anisotropy of Volume Change and Permeability in Hard Sandstones under Triaxial Stress Conditions

Flora Feitosa Menezes, S. Schlüter, J. M. Kühne, K. Svensson, C. Lempp, A. Neumann, H. Pöllmann
Geomechanical effects in a Bunter Sandstone due to impure CO2 injection

Geoffroy Mohn, N. Etheve, D. F. de Lamotte, E. Roca, J. Tugend, J. Gómez-Romeu
Extreme Mesozoic crustal thinning in the Eastern Iberia margin: The example of the Columbrets Basin (Valencia Trough)

Simone Papa, G. Pennacchioni, A. Fioretti, A. Guastoni, A. Langone, L. Secco
The Tertiary pegmatite field of the Central Alps in the southwestern Bergell Pluton: timing of intrusion and implications for the local stress field

Samuele Papeschi
The microstructural record of a 'brittle-ductile transition'

Alessandro Petroccia, M. Simonetti, R. Carosi, C. Montomoli
Kinematics of the flow in the Cavalaire Fault (Maures Massif, SE France): correlation with the transpressional Posada-Asinara shear zone in northern Sardinia

Rabeb Dhifaoui, P. Strzerzynski, R. Mourgues, C. Gourmelen, A. Rigane
Accommodation of a compression continental crust: Analogical modeling of the Tunisian Atlas

Jack Richardson, I. Alsop, C. Magee, C. Stevenson
Revealing the internal flow of salt structures using anisotropy of magnetic susceptibility

Andrea Succo, S. Mittempergher, M. Mozafari, A. Bistacchi, P.-O. Bruna, F. Storti, M. Meda
Along-strike fold shape and deformation style variability in a multiphase fold evolution: insights from the Pag anticline, External Dinarides, Croatia

Norito Takesue, S. Suzuki
Structural development of the Shimanto Belt, SW Japan—based on analysis of Prelithification shear deformation of melange

David M. Taylor, D. Hodgetts, J. Redfern, J. Richardson
Tectonic Compartmentalisation of Braided Fluvial Systems using Digital Outcrop Models

Taija Torvela, D. Grujic, J. Moreau, G. Hetényi
Re-interpretation of the INDEPTH deep seismic profiles (Himalaya)

Julie Tugend, G. Mohn, G. Manatschal, E. Masini
Influence of rift-inheritance on mountain building processes: a point of view based on the Western Pyrenees and Western Alps

Christopher J. Tulley, Å. Fagereng, K. Ujiie
Slow earthquake phenomena – perspectives from subduction mélange exposed on Kyushu Island, Japan

Monday

Session 1. Chair: Taija Torvela
9:15 Welcome

9:30 KEYNOTE: **Rebecca Bell**, M. Gray, J. Morgan, S. Henrys, D. Barker, P. Barnes, L. Wallace, D. Saffer, K. Petronotis, the IODP Expedition 375 and Expedition 372 shipboard scientists
Unlocking the secrets of slow slip using next-generation seismic experiments and IODP drilling at the north Hikurangi margin, New Zealand

10:00 **Adriana Georgina Flórez Rodríguez**, K. Ogata
Deformation and fluid flow associated to the Subligurian nappe detachment: insights from the Cinque Terre area (Northern Apennines, Italy)

10:15 **Filippo Carboni**, S. Back, M. R. Barchi
Comparison between two deep-water fold-and-thrust belts: Outer Tuscan Nappe (Northern Apennines, Italy) vs. Baram DWFTB (NW Borneo)

10:30 Discussion
10:45-11:15 Break

Session 2. Chair: Rob Butler

11:15 **Shoufa Lin**
Promontory collision and the early Paleozoic Wuyi-Yunkai orogeny in South China

11:30 **Ezequiel R. Olaizola**, F. Bechis, D. L. Yagupsky, D. M. Bran, S. Oriolo
Geology and structure of the area around Paso de las Nubes, North-Patagonian Andes, Argentina

11:45 **Matteo Simonetti**, R. Carosi, C. Montomoli
Shear deformation in the Southern European Variscan Belt: kinematic of the flow and geochronological constraints

12:00 **Alessandra G. Pellegrino**, B. Zhang, F. Speranza, R. Maniscalco, C. Hernandez-Moreno
Pattern of deformation and vertical-axis rotation in strike-slip fault zone (Yunnan, China)

12:15 **Thierry Dumont**, S. Schwartz, S. Guillot, P. Monié, S. Matthews, M. Jouvent
Kinematics of the early Alpine collision wedge recorded in the internal zones of the western Alps

12:30 Discussion
12:45-14:00 Lunch

2nd July

Session 3. Chair: Thierry Dumont

14:00 **Manuel Ignacio de Paz-Álvarez**, J. L. Alonso, L. P. Fernández
Gravity-driven structures and deposits resulting from slope collapse in the margin of a carbonate platform (Pennsylvanian, Cantabrian Zone, NW Iberia)

14:15 **Sian L. Evans**, C. A.-L. Jackson
The Influence of Base Salt Relief on the Structural Evolution of Salt and Overburden: Case Study from the Outer Kwanza Basin, offshore Angola

14:30 **Laura Burrell**, A. Teixell
Exploring the role of salt tectonics in the South-Pyrenean fold-and-thrust belt

14:45 **Camilo Ruiz**, A. Teixell
Role of salt detachment in the fold belt of the axial zone of the Eastern Cordillera, Northern Andes

15:00 Discussion

15:15 Field trip briefing - Alpine setting - Rob Butler

15:45-17:00 Posters with refreshments

Notes

Wednesday 4th July

Session 4. Chair: Rodolfo Carosi

9:30 KEYNOTE: **David Wallis**, L. N. Hansen, T. B. Britton, A. J. Wilkinson
High-angular resolution electron backscatter diffraction analysis of lattice distortion in geological materials.

10.00 **Pratheesh Prabhakaran Nair**, V. Chandrasekharan, P. Vasudevakaimal
Microstructural significance of the mylonites from the Achankovil shear zone, South India

10:15 **Diana Avadanii**, L. Hansen, A. Wilkinson, K. Marquardt
Micromechanical investigation of olivine grain boundaries

10:30 Discussion
10:45-11:15 Break

11:15 Briefing and workshop for Chenaillet field excursion. Rob Butler and Taija Torvela
12:45-14:00 Lunch

Session 5. Chair: Thierry Dumont

14:00 Amicia Lee, **T. Torvela**, G. L. Lloyd, A. Walker
'Fake mylonites': Melt organisation, strain partitioning, and rapid freezing in the lower crust

14:15 **Chiara Montemagni**, C. Montomoli, S. Iaccarino, R. Carosi, I. M. Villa
Two opposite kinematics shear zones in the Alaknanda – Dhauli Ganga valleys (NW India): insight from microstructural and geochronological investigations

14:30 **Samuele Papeschi**
Strain localization in quartz-rich rocks at the brittle-ductile transition

14:45 **Stefano Ghignone**, V. Van Schijndel, S. Ferrero, M. Gattiglio, A. Borghi, G. Balestro, I. Gasco
New structural and petrological data for the Susa Shear Zone (mid-Susa Valley, Western Alps): Constraints on a polyphasic shear zone between eclogite and blueschist units

15:15 **Rodolfo Carosi**, C. Montomoli, S. Iaccarino
Constraining the evolution of HT shear zones in the Himalayan mid crust: fusing structural geology and petrochronology

15:30 **Salvatore Iaccarino**, R. Carosi, C. Montomoli, C. Montemagni, H.-J. Massonne, A. K. Jain, I. M. Villa, D. Visonà
The Himalayan metamorphic core along the Alaknanda-Dhauli Ganga valley (Garhwal Himalaya, India)

15:45 Discussion
16:00-17:00 Posters with refreshments

Friday 6th July

Session 6. Chair: Rob Butler

9:30 KEYNOTE: **Geoffroy Mohn**, B. Petri, T. Duretz, S. M. Schmalholz, O. Müntener
Thinning mechanisms of the continental lithosphere: contribution from the Alpine Tethys rifted margins

10:00 **Fabrizio Cocco**, A. Funedda, E. Patacca
The Campidano Graben (Italy): a Pleistocene re-activation of the Oligo-Miocene fault system of southern Sardinia

10:15 **Samuel C Boone**, A. J. W. Gleadow, B. P. Kohn, C. Seiler, C. K. Morley, D. A. Foster
Rift superposition in the Turkana Depression and the birth of the East African Rift System

10:30 Discussion

10:45-11:15 Break
11:15 Discussion - insights from field excursions - sharing opinions and interpretations
12:45-14:00 Lunch

Session 7. Chair: Rodolfo Carosi

14:00 **Rob Butler**, J.T. Eggenhuisen, P. Haughton, W.D. McCaffrey,
Deformation of sediments during turbidite deposition - a kinematic boundary layer approach

14:15 **Pablo Rodriguez-Salgado**, C. Childs, P. Shannon, J. Walsh
Structural evolution of the Mizen Basin (Celtic Sea, Offshore Ireland) with special reference to basin inversion

14:30 **Billy Andrews**, Z. Shipton, R. Lord
The internal structure and development of faults cutting coal bearing stratigraphy

14:45 **Craig Magee**, C. A-L. Jackson
The 3D structure and growth of dykes and dyke-induced normal faults

15:00 Discussion
15:15-15:45 Break

Session 8. Chair: Taija Torvela

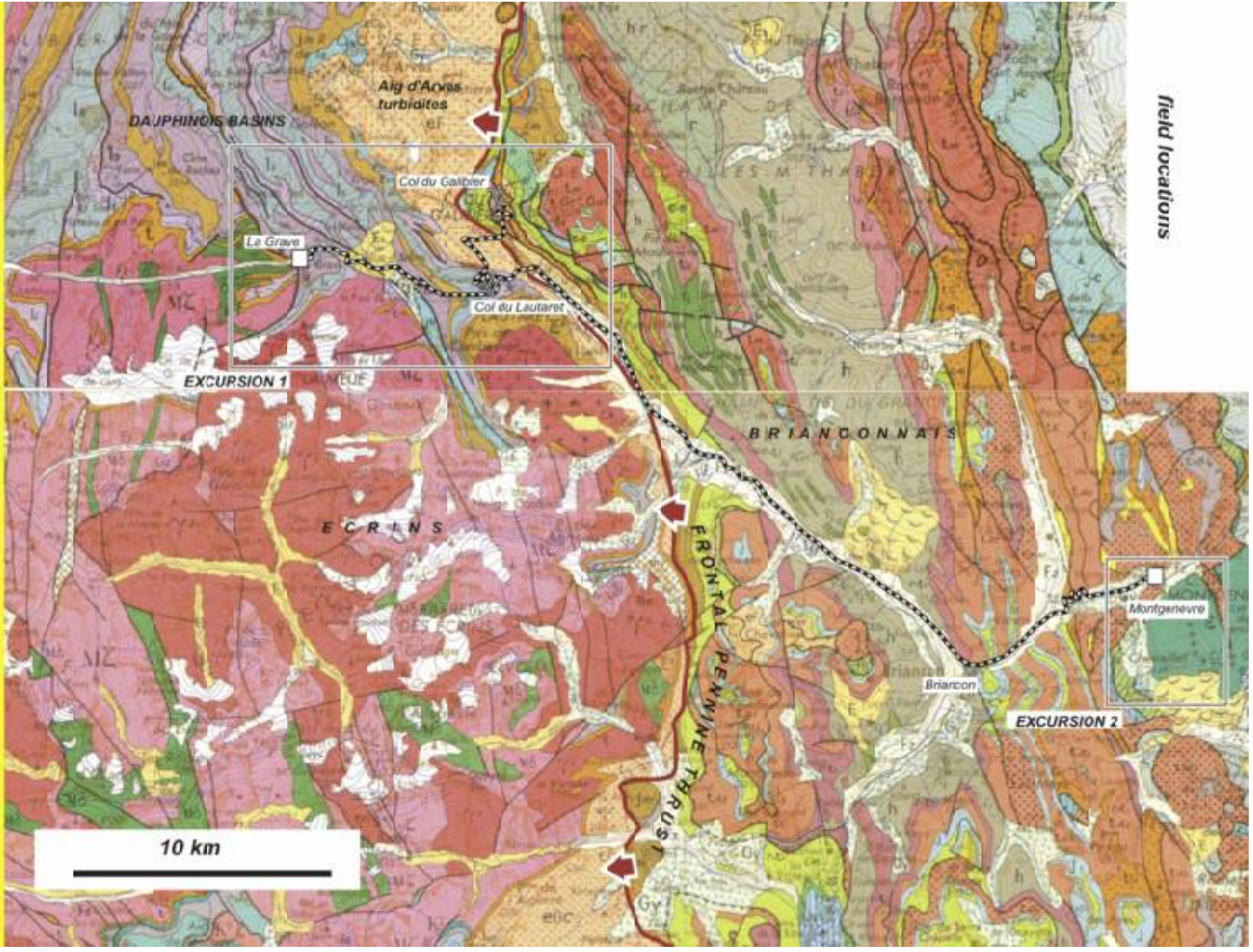
15:45 **Stefan Vollgger**
Photogeology in the 21st century - 3D structural analysis from digital photographs

16:00 **Adam J. Cawood**, C. E. Bond, H. Watkins, M. Cooper, M. J. Warren
Multiple influences on measured fracture attributes in a frontal anticline: a case study from the Sawtooths, NW Montana

16:15 **Dave McCarthy**, T. Dodd
Structural variation across a submarine fold and thrust belt, South Falkland Basin

16:30 **Matias Barrionuevo**, J. Mescua, L. Giambiagi, J. Suriano, H. de la Cal, J. L. Soto, E. Stahlschmidt
Strain and stress field evolution in the Andean orogenic front between 35-36°S and its link with fluid migration

16:45 Discussion
17:00 Close

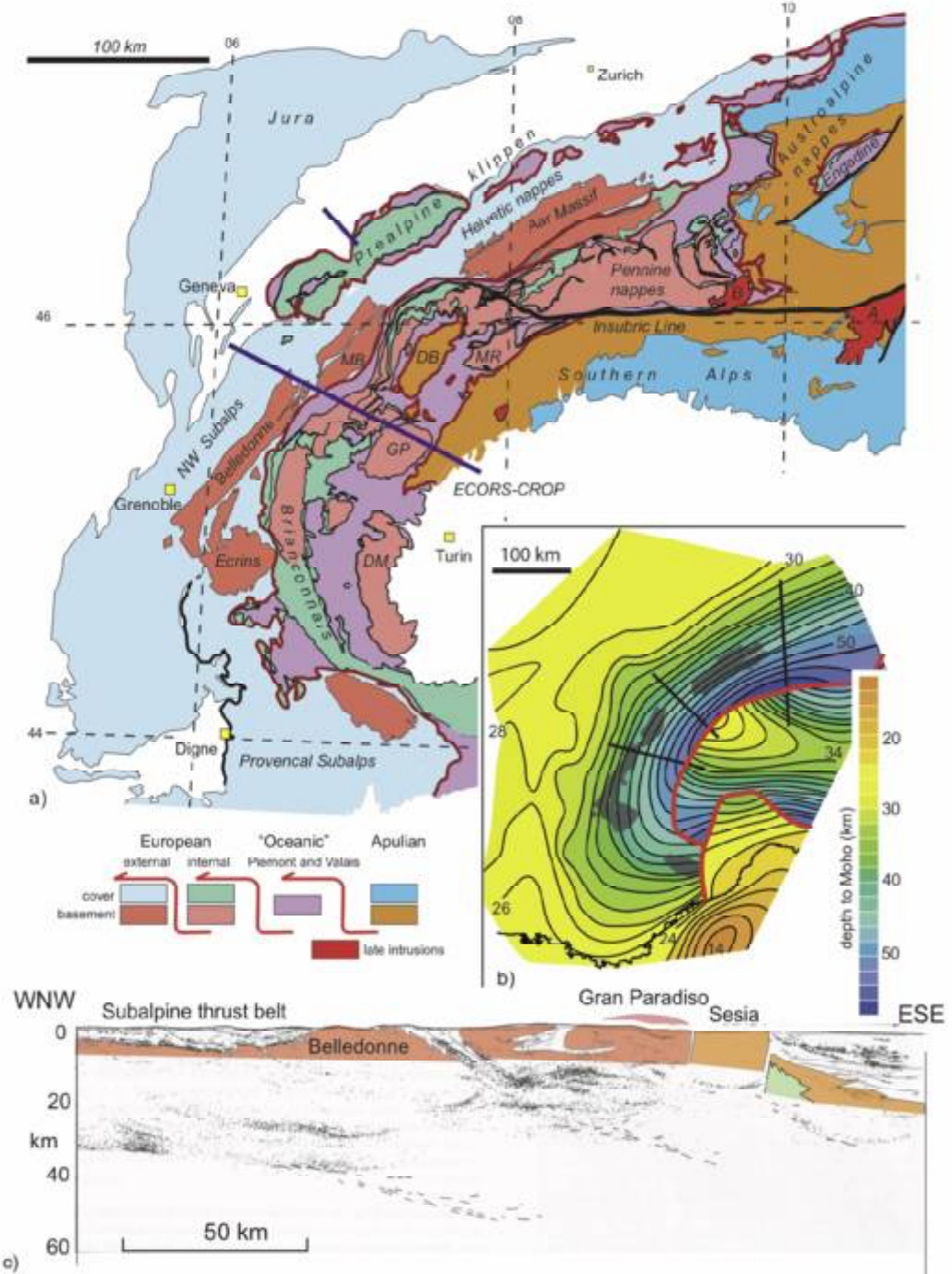

field locations
Aig d'Arves turbidites
DAUPHINOIS BASINS
Col du Galibier
Le Grave
Col du Lautaret
EXCURSION 1
BRIANCONNAIS
ECRINS
FRONTAL PENNINE THRUST
Montgenevre
Briançon
EXCURSION 2
10 km

Guide to field excursions

Two days of field excursions are designed to introduce a diversity of structural and tectonic geology using outcrops in the vicinity of Montgenèvre. The first few pages of the guide provide diagrams that give context, with regional Alpine maps, cross-sections. These are followed by more detailed information relating to the two distinct excursions. The first of these visits inverted basin structures and Alpine thrust zones, together with structures relating to evaporites mobilized during this deformation. The second excursion concentrates on rifting processes and the structure of the transition between the European continental margin and now-subducted Tethys oceanic lithosphere, but also considers the deformation of the distal continual margin during Alpine orogenesis. Excursions involve close examination of structures together with regional views.
Note – safety briefing notes are available separately.

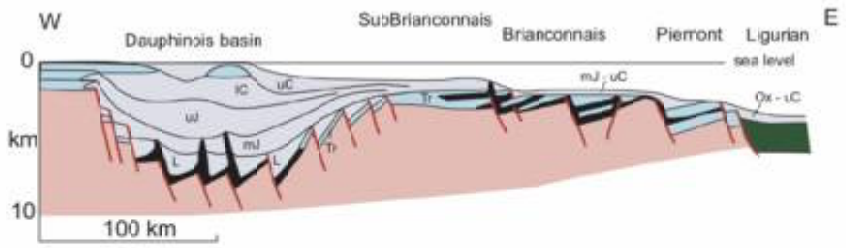
Brief tectonic notes

The western Alpine orogen is an expression of the tectonic convergence between the Apulian continental block (largely the Italian peninsula) and the rest of Europe, following the consumption of the intervening Piedmont (western Tethyan) ocean floor. Much of the present-day structure of the Alps relates to these processes, which culminated through the Oligo-Miocene with significant crustal shortening leading to the rise of the modern Alpine chain. However, Alpine outcrops allow us to look back into earlier geological history, most strikingly relating to the early rifting and formation of the ancestral continental margin of Europe with the fledgling western Tethyan ocean (in the Jurassic). We are concerned with rocks from the European continental margin, how these were rifted and then how these rift systems were subducted, restacked and exhumed during Alpine orogenesis. This history provides a good range of tectonic structures for study but also makes deducing their inter-relationships highly uncertain. Pulling together these tectonic stories is necessarily multi-disciplinary – involving disciplines beyond structural geology, especially relying on stratigraphic and sedimentological data to constrain timing and subsidence records in the precursor basins. Likewise a variety of palaeothermal/ barometric and geochronological tools are needed to establish burial, exhumation and related timing issues.

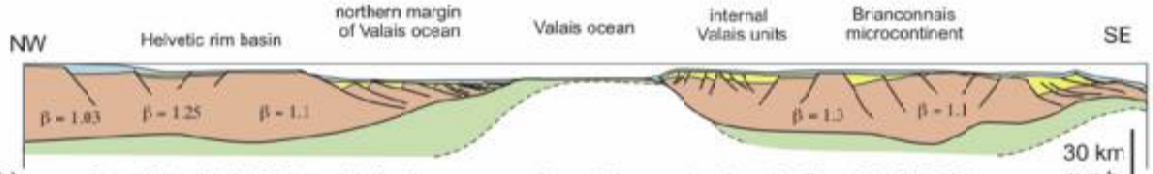


(a) Simplified tectonic map of the Western Alps; (b) depth to Moho, and (c) line-drawing of the ECORS-CROP deep seismic profile (all images from Butler 2013)

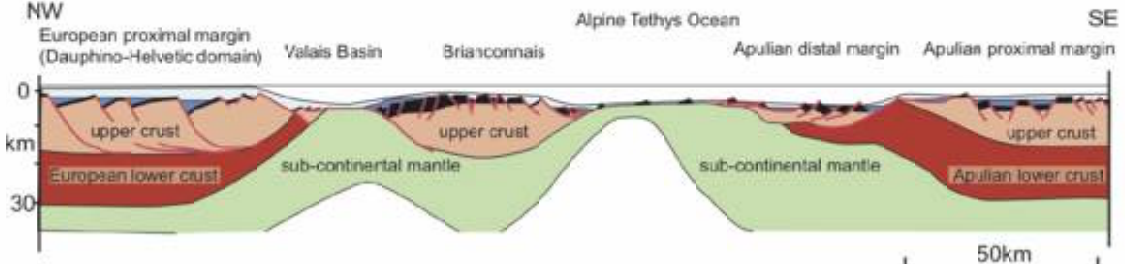
Templates for variations in pre-orogenic Alpine stratigraphy and crustal thickness.



a) *Lemoine et al.'s (1986) stratigraphic model for the western Alps, drawn for an E-W transect through the Grenoble-northern Pelvoux area. Dauphinois basin corresponds to the external Alps.*

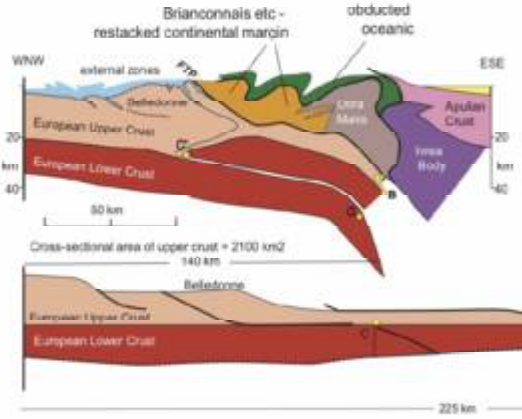


b) *Stampfli et al.'s (1998) template for the pre-orogenic crustal geometry along the line of the NRP-20 Western transect. The Valais ocean corresponds to the sub-Brianconnais domain of Lemoine et al (1986).*



c) *is an equivalent transect to that of (b) and illustrates the conjugate margin model of Mohn et al. (2010).*

Crustal balancing - auditing continental crust through the rift to collision history of the Western Alps

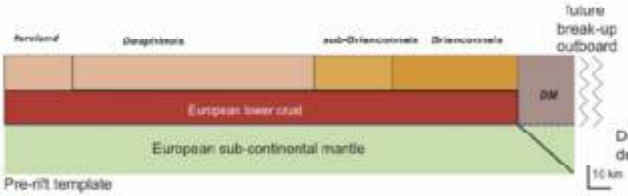


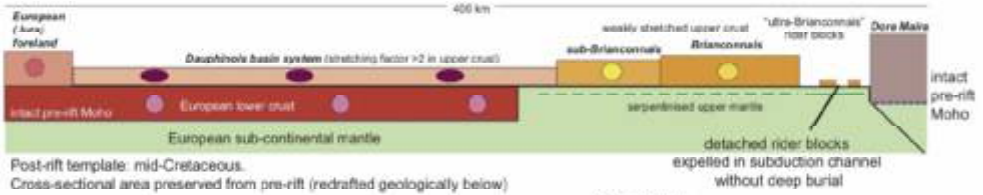
Highly simplified crustal cross-section - generalised for the Western Alps - showing Schmid et al's (2004) notion of "rigid" lower crust beneath the external zones. The External upper crust is shown with significant internal strain - outcropping in the External Basement Massifs (e.g. Belledonne).

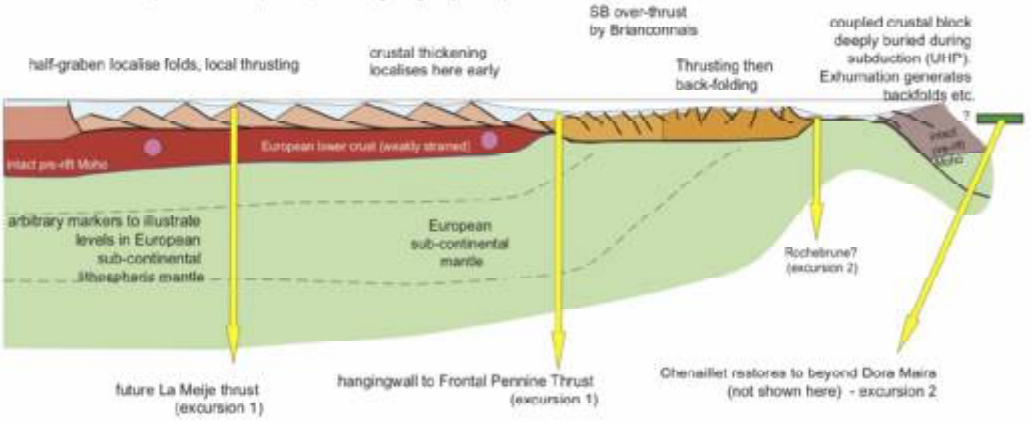
This shows a restoration of the external zones - assuming 85 km shortening on all structures below the Frontal Pennine Thrust (and plane strain). Note that the upper crust cannot restore across the width to have a thickness of that in the foreland. Therefore the crust has thinned (i.e. by Jurassic rifting).

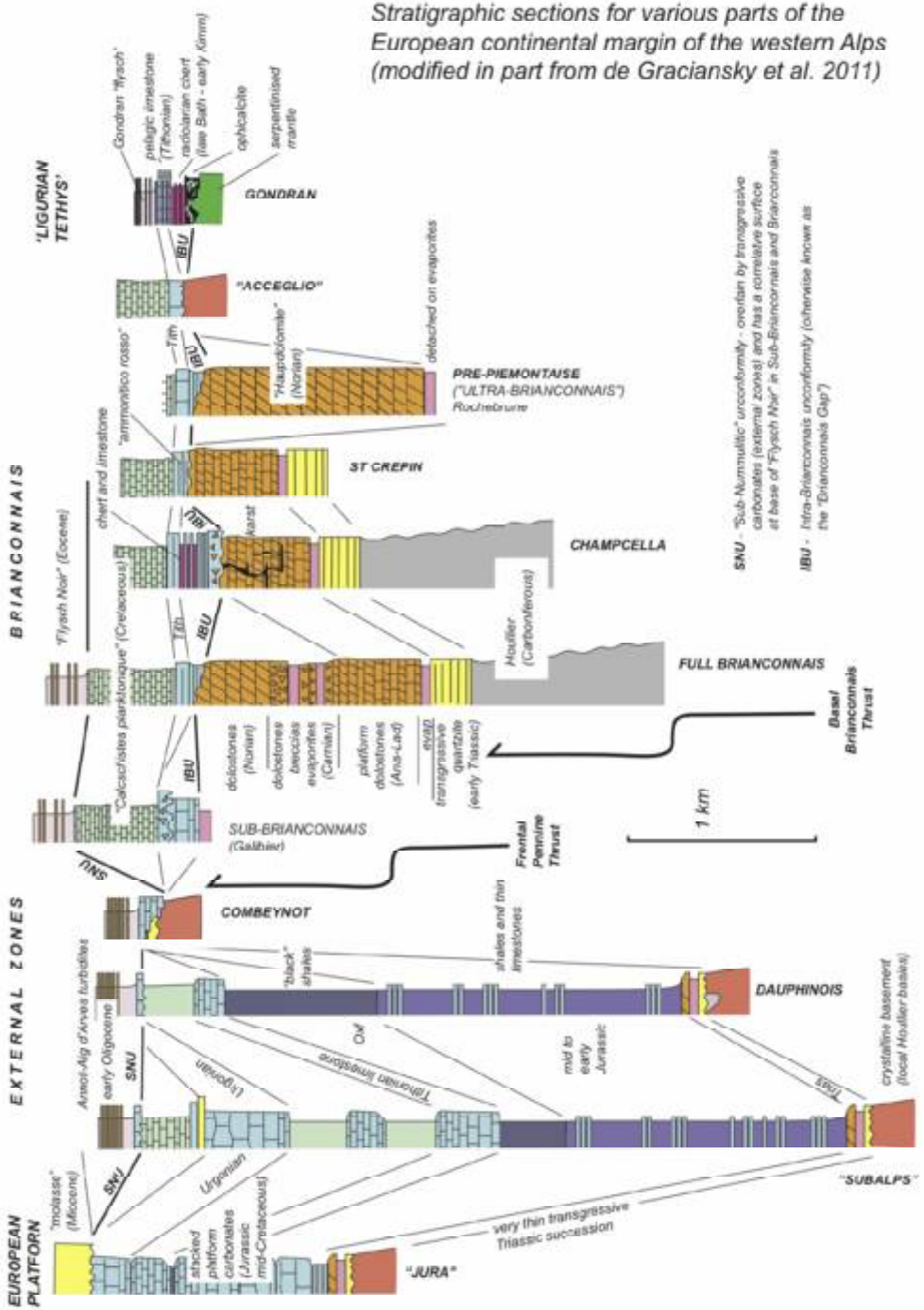
The lower template restores the upper crust of the external zones to its thickness in the foreland - which then only partly covers the restored lower crustal width. To achieve a pre-rift balance more upper crust is needed to overlie this lower crustal panel - here shown as the upper crust of the Sub-Brianconnais and Brianconnais zones.

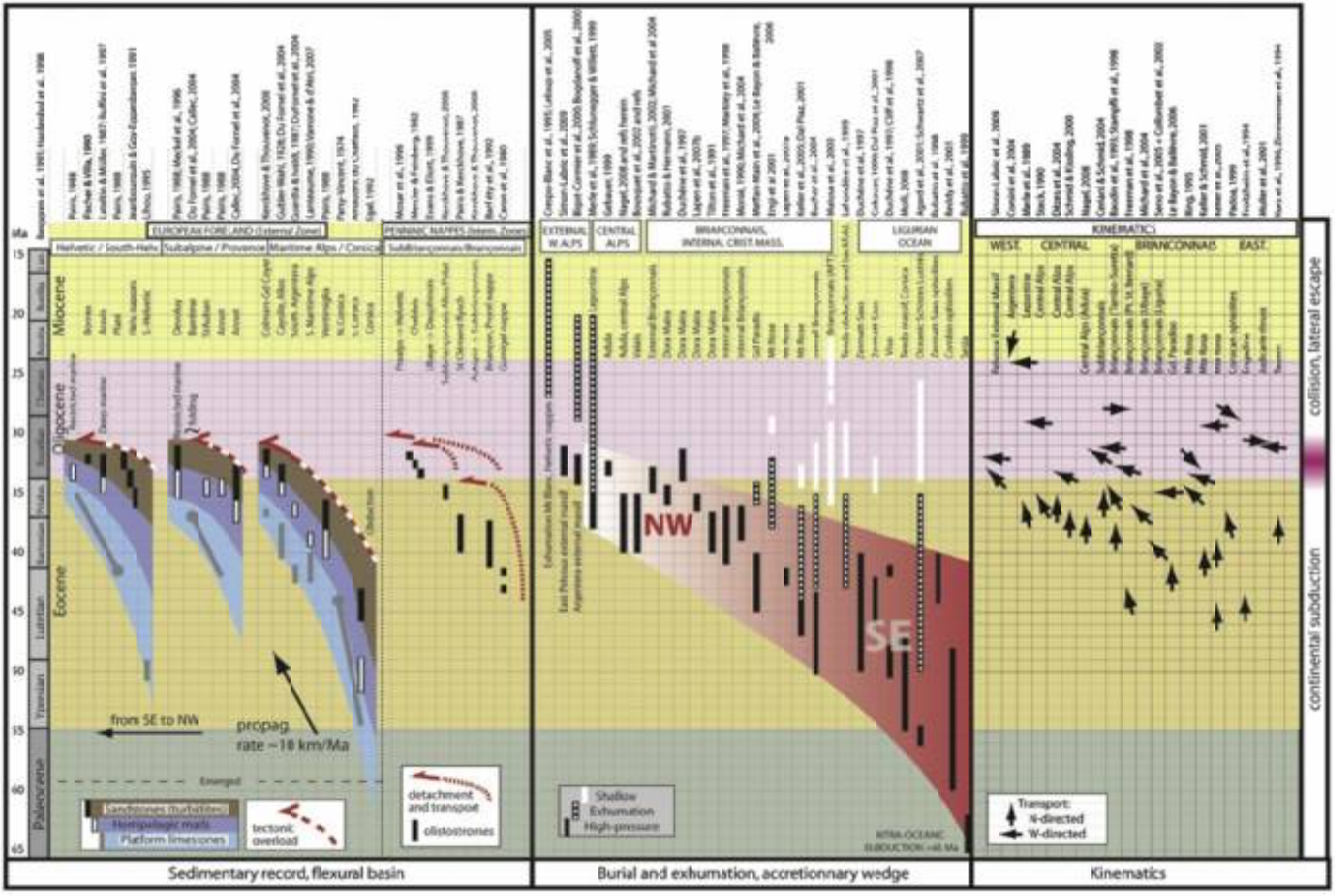
The highly schematic block model charts the cross-sectional areas of crust as the pre-rift template evolves into the post-rift template. Note that this model re-distributed crust and is expected to generate contrasting histories of vertical motion - which will in turn be reflected in the stratigraphy (after Butler 2013, J Struct Geol).



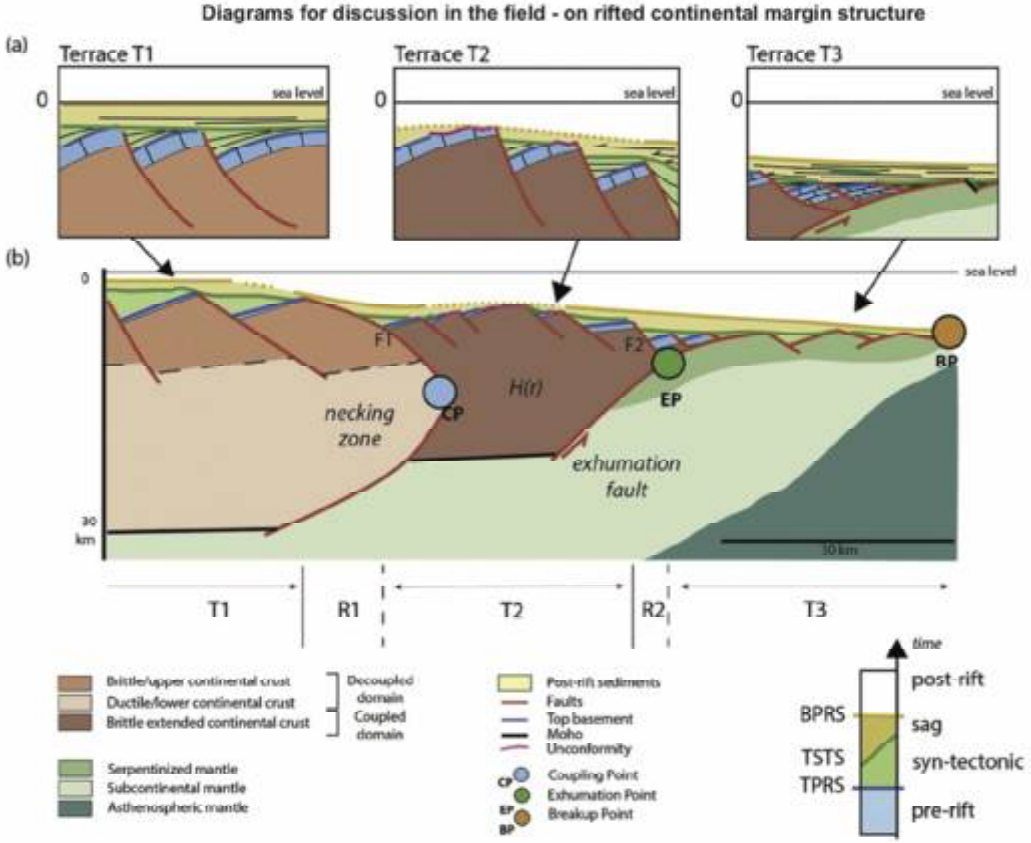




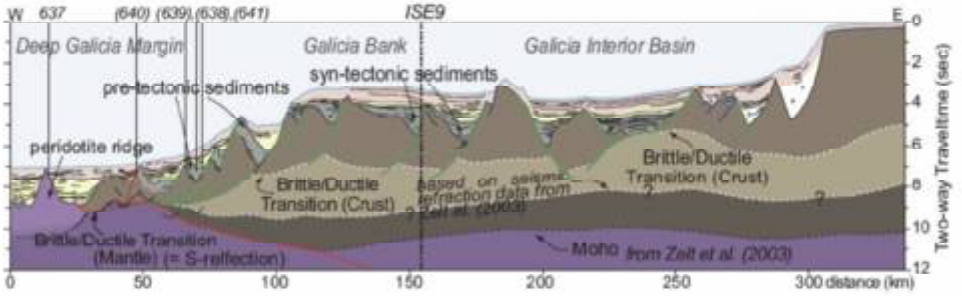

Stratigraphic sections for various parts of the European continental margin of the western Alps (modified in part from de Graciansky et al. 2011)
'LIGURIAN TETHYS'
BRIANCONNAIS
EXTERNAL ZONES
EUROPEAN PLATFORM
Gondran "flysch"
pelagic limestone (Tithonian)
radiolarian chert (late Bath - early Kimm)
ophicalcite
serpentinised mantle
GONDRAN
IBU
"ACCEGLIO"
"ammonitico rosso"
"Haupdolomit" (Norian)
detached on evaporites
PRE-PIEMONTAISE ("ULTRA-BRIANCONNAIS")
Ruchrebrune
ST CREPIN
chert and limestone
"Flysch Noir" (Eocene)
"Calcschistes plaitoniques" (Cretaceous)
Karst
CHAMPCELLA
Houiller (Carboniferous)
FULL BRIANCONNAIS
Basal Briançonnais Thrust
dolostones (Norian)
dolostones breccias evaporites (Carnian)
platform dolostones (Ani-Ladi)
evap. transgressive quartzite (early Triassic)
SUB-BRIANCONNAIS (Gallhieu)
Frontal Pennine Thrust
1 km
COMBEYNOT
Annot-Alg d'Arves turbidites
early Oligocene
"black" shales
shales and thin limestones
DAUPHINOIS
crystalline basement (local Houiller basins)
Oxf
mid to early Jurassic
Toarcian limestone
Lyonnais
Toarc
SNU
SNU
"molasse" (Miocene)
Urgonian
stacked platform carbonates (Jurassic mid-Cretaceous)
very thin transgressive Triassic succession
"SUBALPS"
"JURA"
SNU - "Sub-Nummulitic" unconformity - overlain by transgressive carbonates (external zones) and has a correlative surface at base of "Flysch Noir" in Sub-Briançonnais and Briançonnais
IBU - Intra-Briançonnais unconformity (otherwise known as the "Briançonnais Gap")



Compilation of stratigraphic and radiometric constrairnts on the tming of Alpine orogenesis, by Durront et al. (2012, J. Geodynamics)

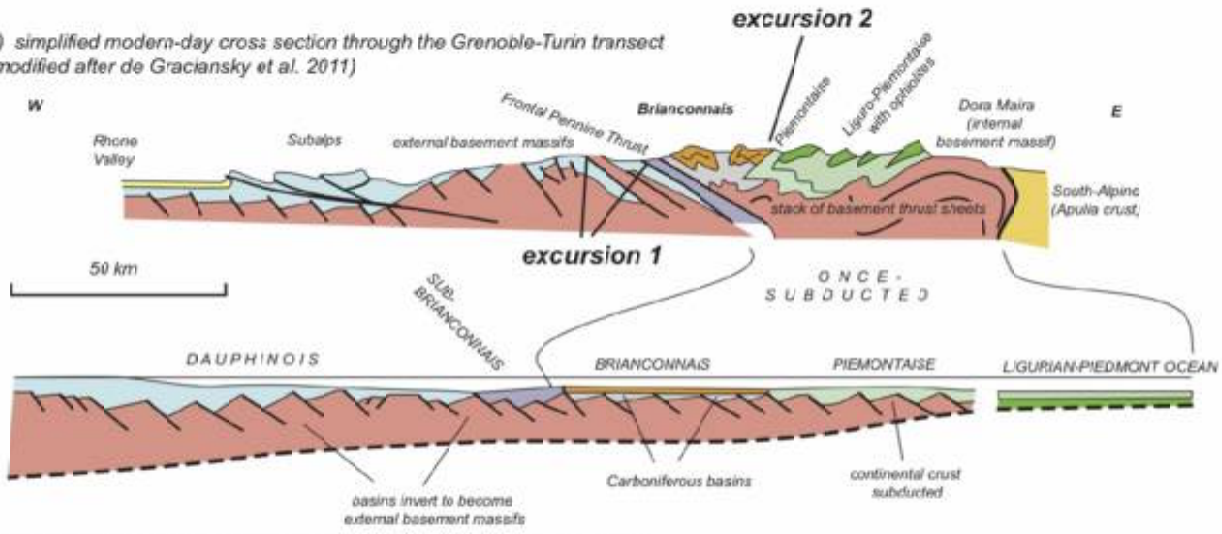


Haupert et al.'s (2016; Mar. Petrol. Geol.) model for "upper plate" rifted continental margins



Interpretation based on 2D seismic reflection profiles and IOPD (etc) wells of the Iberian continental margin of the Eastern Atlantic. From Peron-Pinvidic & Manatschal (2008, Int J Earth Sci)

a) simplified modern-day cross section through the Grenoble-Turin transect (modified after de Graciansky et al. 2011)



b) schematic restored template (modified after de Graciansky et al. 2011, based on the restoration of Lemoine et al. 1986)

Excursion 1: La Meije and Col du Galibier

Barre des Ecrins (L) and La Meije group from Col du Galibier. Basal Briançonnais Thrust in foreground.

Aims: to examine a basement thrust zone, with regional views of thrust geometry and inverted half-graben, followed by the Frontal Pennine Thrust and its relationship to remobilized Triassic evaporites.

Itinerary

Depart Montgenevre and drive over the Col du Lautaret to La Grave (about an 75 mins).

1.1 - La Grave

The lower lift station gives contextual views ahead.

Take the cable car (two legs) up to the top station (check out La Meije thrust in cliff-sections on the way up).

1.2 - Ruillins top station (c 3200m)

Great views north across the Dauphinois basins, the Tertiary "foredeep" deposits and - if lucky - all the way to Mont Blanc. La Meije (Alpine) thrusting, Triassic dolostones.

Return down to La Grave.

1.3 La Grave

Jurassic black shales with complex deformed vein arrays (roadside).

Drive back up East on N91

1.4 Col du Lautaret

Panoramic views across the Frontal Pennine Thrust to the north - context for next stop.

1.5 roadsection below Galibier

The Frontal Pennine Thrust, highly veined Jurassic limestone on deformed turbidites.

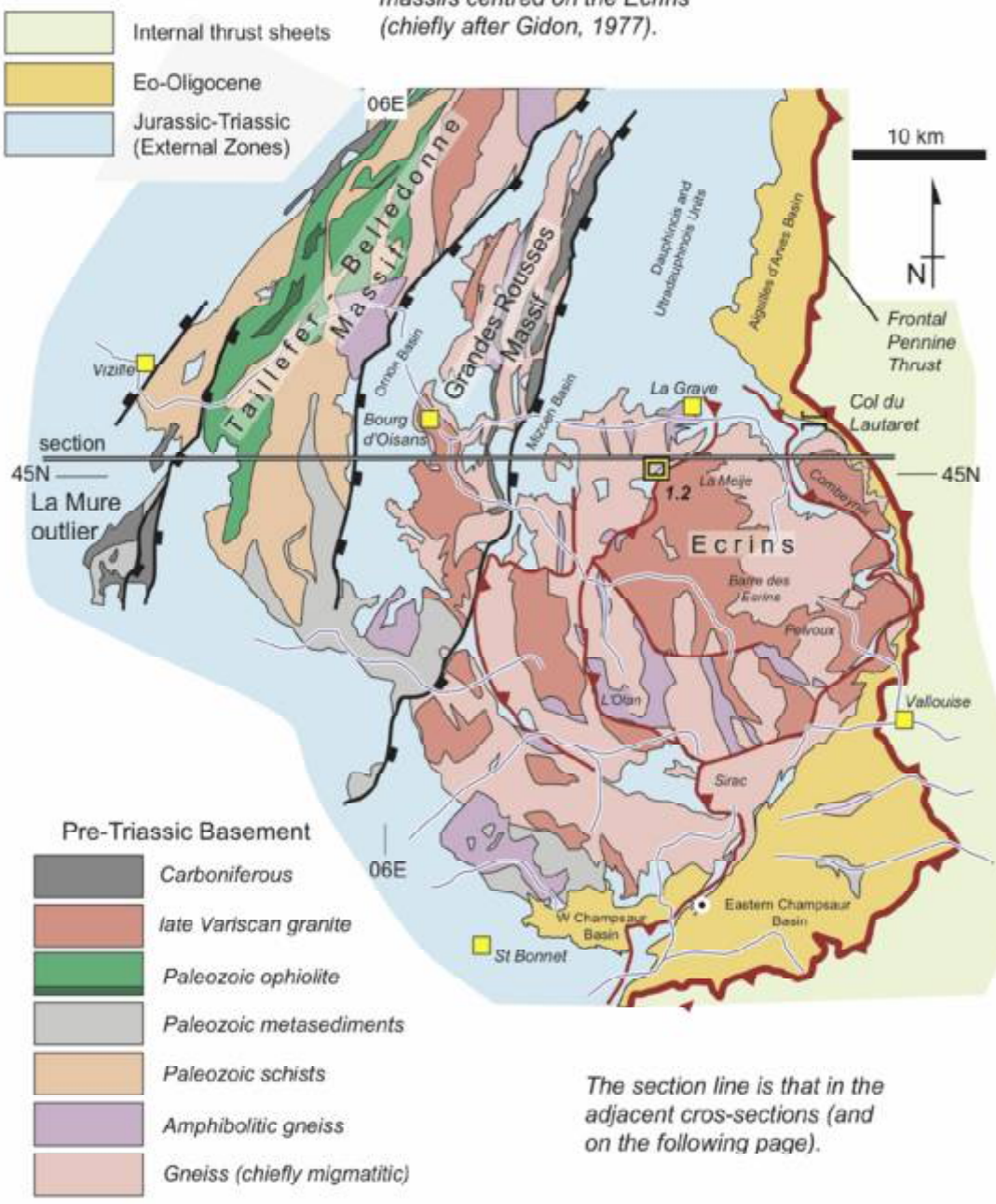
Drive up to Galibier - stopping at the lower carpark and ascend the final hairpins to the col proper.

1.6 Col du Galibier

A walk around a salt (gypsum) body that apparently punctures the thrust system.

Drive down to the Guisanne Valley to Briancon. Visit planned to the Geopark's Maison de Geologie.

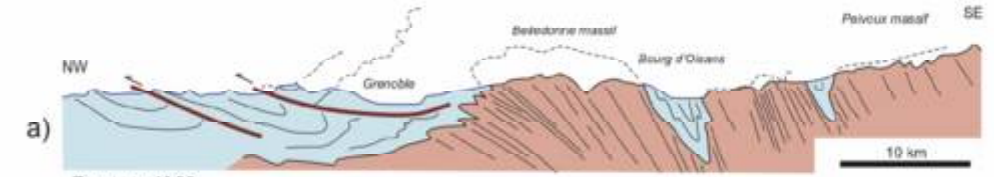
Simplified geological map of the external basement massifs centred on the Ecrins (chiefly after Gidon, 1977).



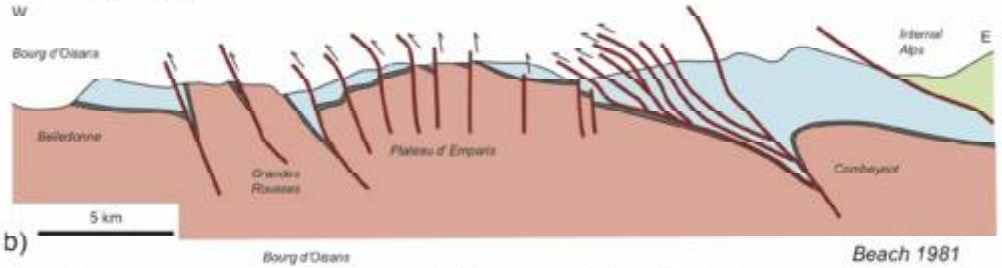
The section line is that in the adjacent cros-sections (and on the following page).

Various interpretations of basement structure - Ecrins Massif

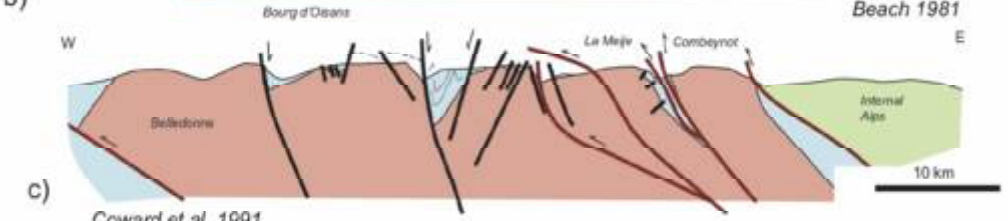
These interpretations show "pinched-in" synclines due to interfacial buckling (a), exclusively thrust tectonics (b), inversion tectonics (c), modified in (d). (e) shows a linked shear zone model. In all, basement is pink and cover is blue, with internal thrust sheets in green.



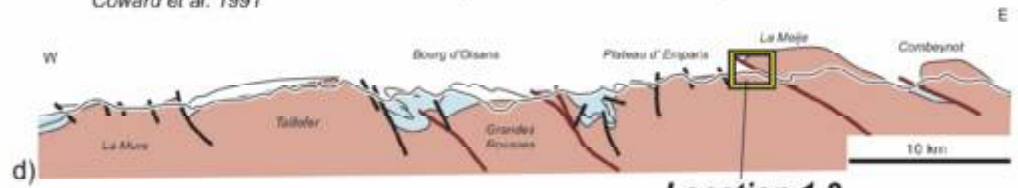
Ramsay 1963



Beach 1981

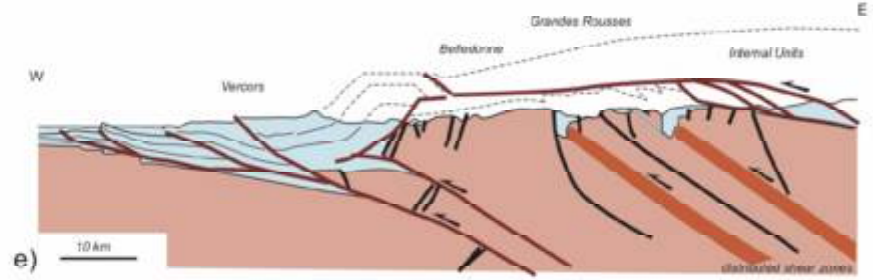


Coward et al. 1991

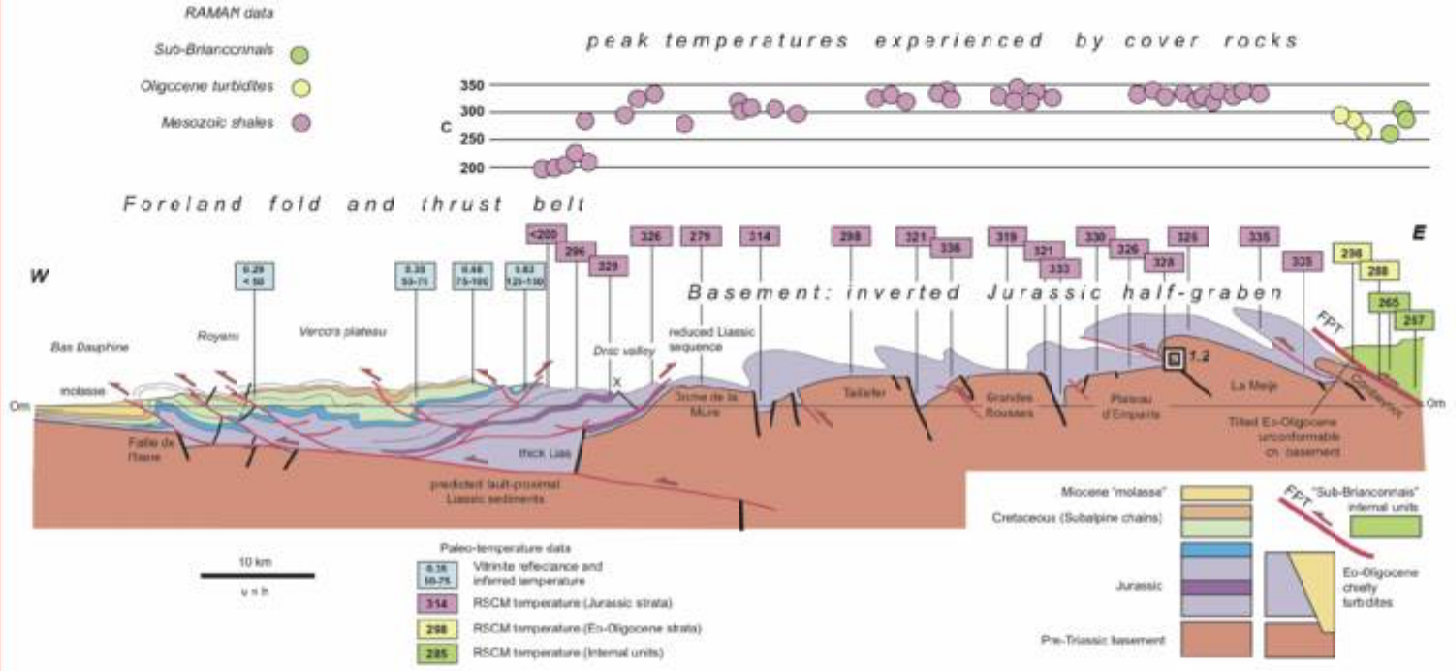


Dumont et al. 2008

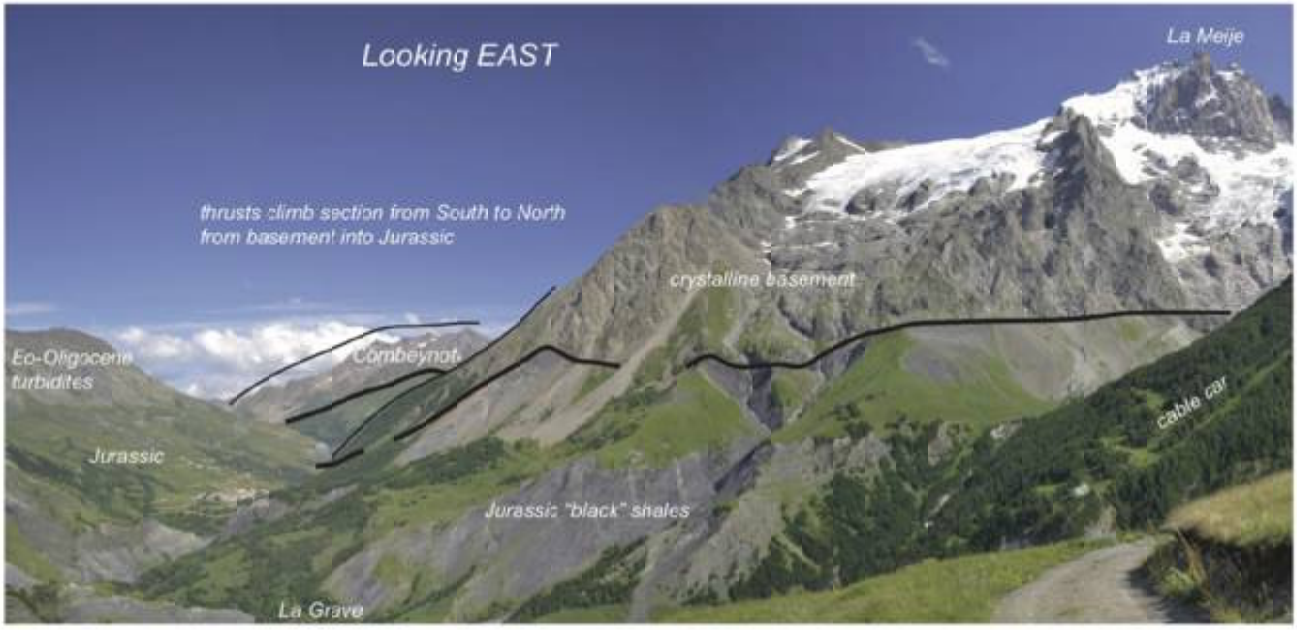
Location 1.2



Bellahsen et al. 2012

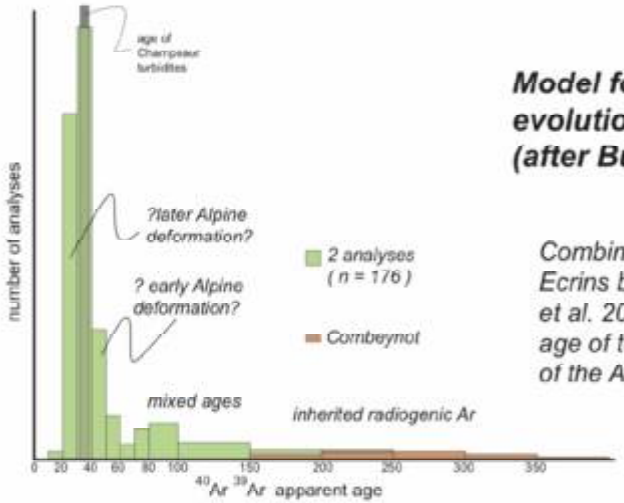


Context for the visit to La Meije Thrust.
Simplified regional cross section (located on map overleaf) showing the chief structural elements in the external western Alps, along a transect from the Vercors to the Frontal Penrine Thrust just east of the Combeynot massif. The thermal data are after Bellanger et al. (2015) and display peak temperatures recorded in sedimentary rocks.

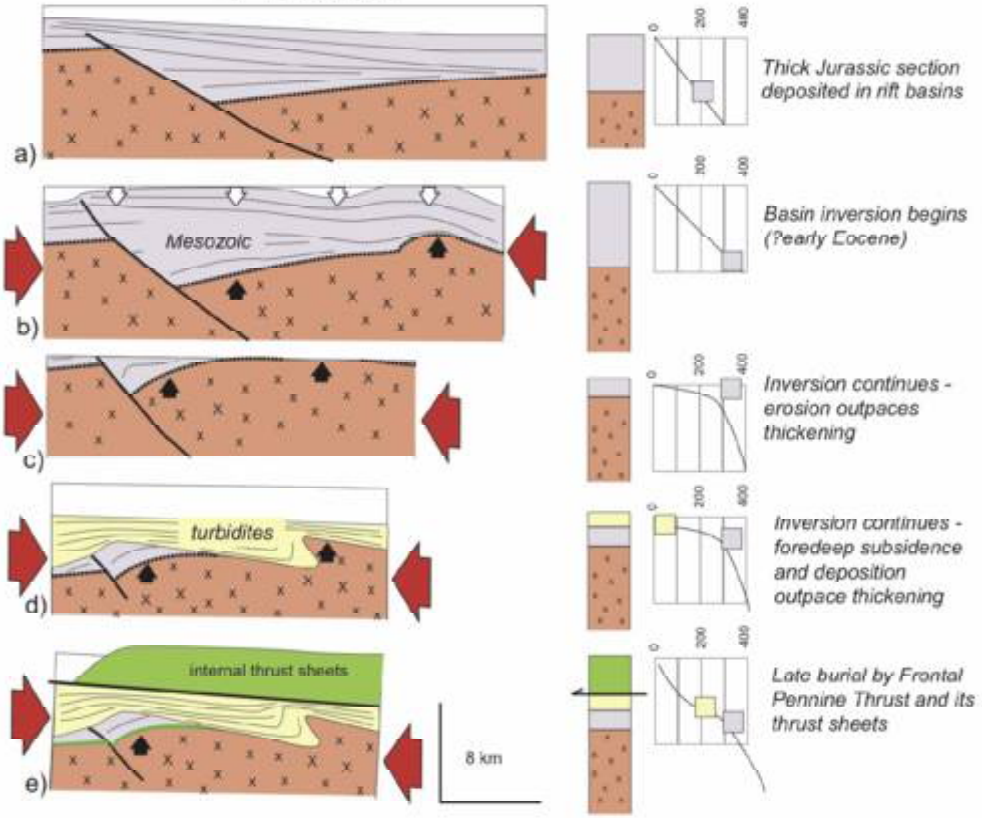


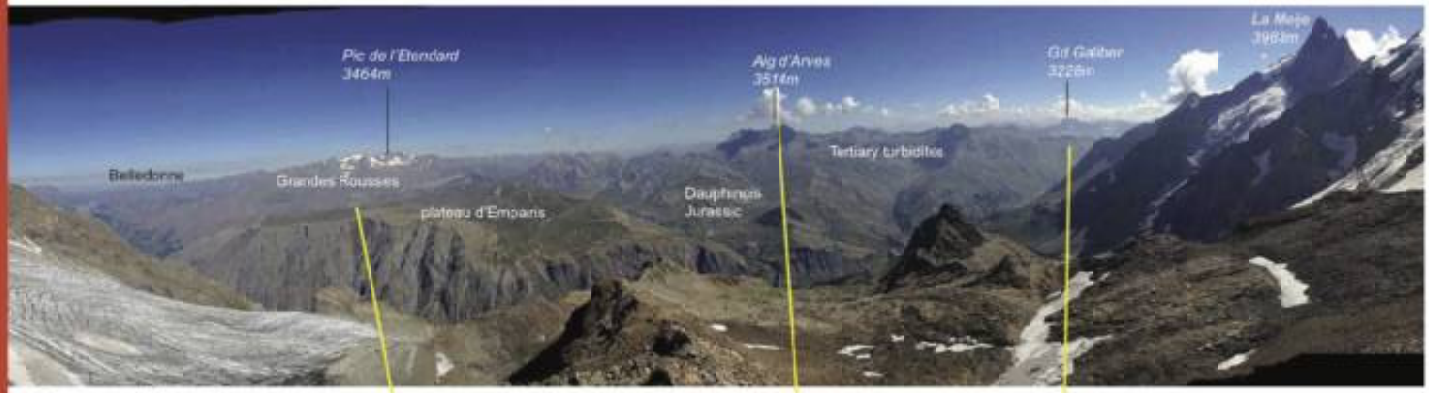
The Alpine thrusts that stack basement to form the Ecrins massif dramatically climb section from South to North, up into Jurassic cover - thereby defining the northern edge of the massif.
The Jurassic strata, dark-to-black shales, contain vein arrays ("beefs") which are well-exposed in road sections above La Grave village (optional stop if weather not suitable for high ground).

Model for thermo-structural evolution of the Ecrins sector (after Butler 2017)

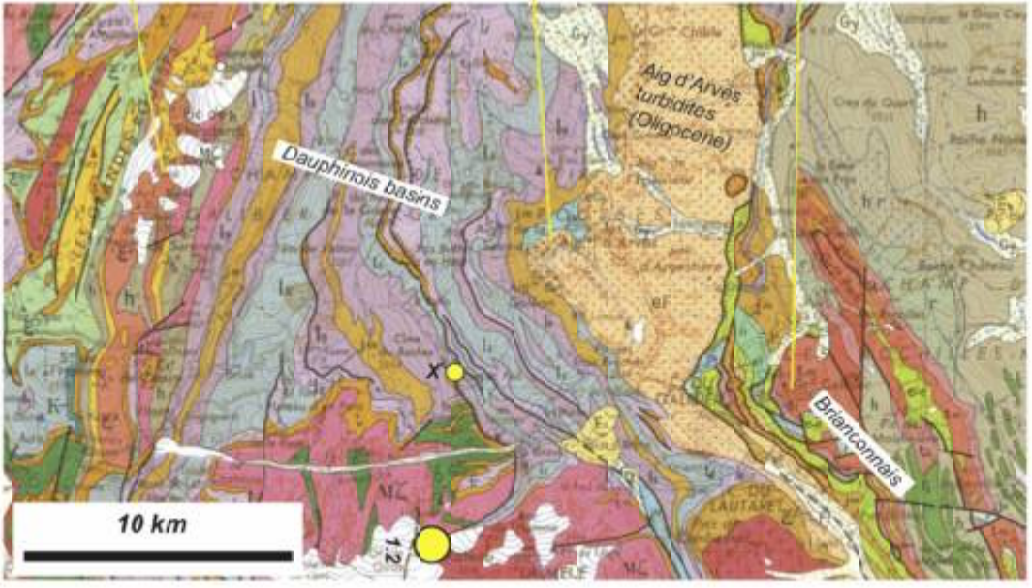


Combined Ar isotopic data for Ecrins basement (after Bellanger et al. 2015), together with depositional age of turbidites - lateral equivalent of the Aiguilles d'Arves system.





Panorama north from near the upper cable car station (location 1.2)

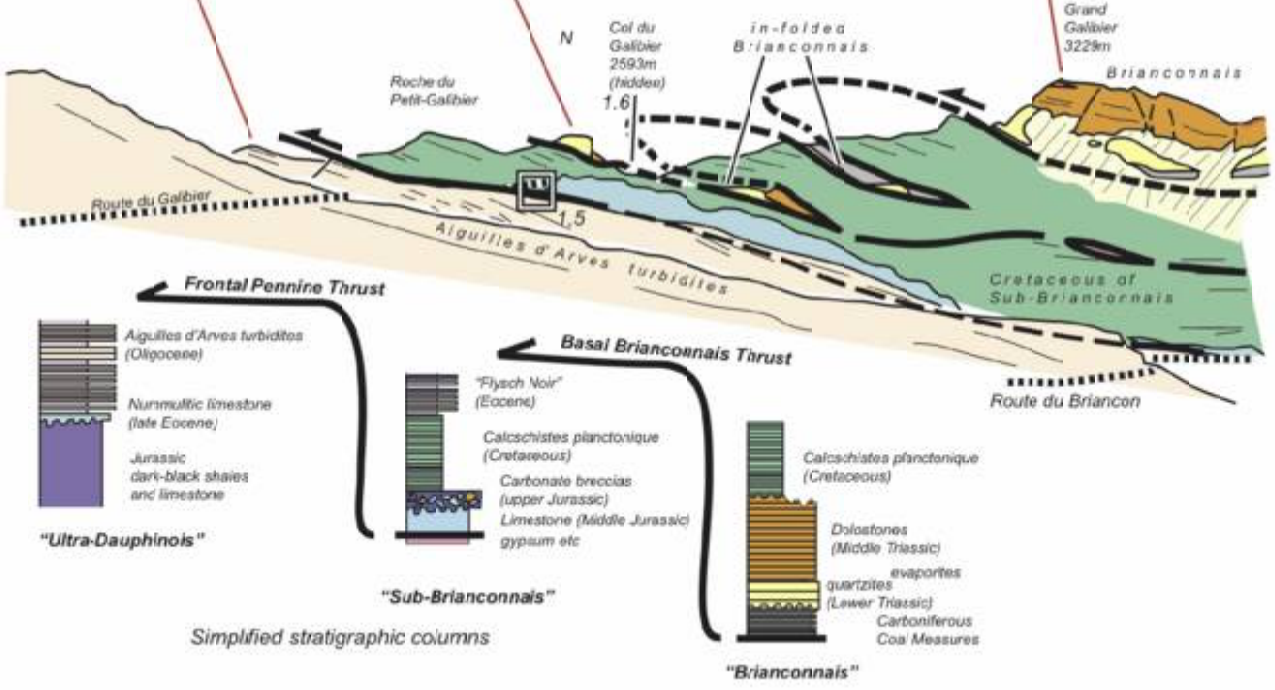


The view North from location 1.2. X is the viewpoint used to depict the South-to-North climb of thrusts from basement to cover (not visited on excursion).

La Meije thrust seen below the now-retreated eponymous glacier - carrying pre-Triassic crystalline basement onto Jurassic shales. Note Grand Galibier in the background.

Location 1.2: the top cable-car station and surroundings. This vantage-point provides excellent views across the width of the former Dauphinois basins. It also gives an insight on how these basins have been inverted during Alpine crustal shortening. The outcrops of La Meije thrust are accessible above the top cable-car station - with excellent top-W shear criteria along chloritic phyllonitic fault-rocks.

View towards Col du Galibier from the Col du Lautaret



Looking east onto the halite-gypsum body at the Col du Galibier (6.4)

Location 1.6 - The Galibier "diapir". Note gneissic banding in the evaporites with entrained limestone - (with earlier vein arrays), the small fragments and entrained cap-rock form pressure-shadows filled fibrous gypsum. The body cross-cuts deformed deformed "Flysch Noir" of the Sub-Briançonnais.

Photographs: (left) Boudinaged and fragmented blocks of Jurassic limestones entrained within the gypsum body. (right) Fibrous gypsum precipitated in pressure shadows around inclusions.

Le Janus and the Ecrins beyond, seen from the top of Le Chenaillet

Aims: to examine deformation associated with the formation of continent-ocean transition zones on rifted margins and aspects of how the margin has been stacked up in the Western Alps.

Itinerary

This is a full day's hiking in hills south of the resort. There are continuous views of the regional structural context.

Depart Montgenevre and take the two lifts (gondola and chair) up to the Sommet des Anges.

2.1 - the top lift station provides panoramic views for scene setting

Descend the slope a few hundred metres.

2.2 - Gondran series

Examine the (now metamorphosed and deformed) succession of limestones and chert - the distal sediments of the rifted margin (late Jurassic). Spectacular extensional crenulation cleavage.

Head south and east down across the meadows

2.3 - ophicalcite

This is the substrate to location 2.1.

Now head NE towards the customs cabin and the start of the geological trail up Chenaillet.

2.4 Serpentinite (and granite)

In a small quarry

Ascend the trail

2.5 Base of gabbro

Labelled as the Moho on the trail. Note sheared gabbros.

And on up

2.6 Gabbro and basaltic dykes

There is one large split boulder with syn-magmatic gabbro fabrics.

Continue to the small platform

2.7 Pillows

A nice small outcrop - check way-up. Note underlying flaser gabbro. .

Ascend the trail to the summit of Le Chenaillet for panoramic views. Then descend the far side (steep) towards the col.

2.8 Oceanic detachment

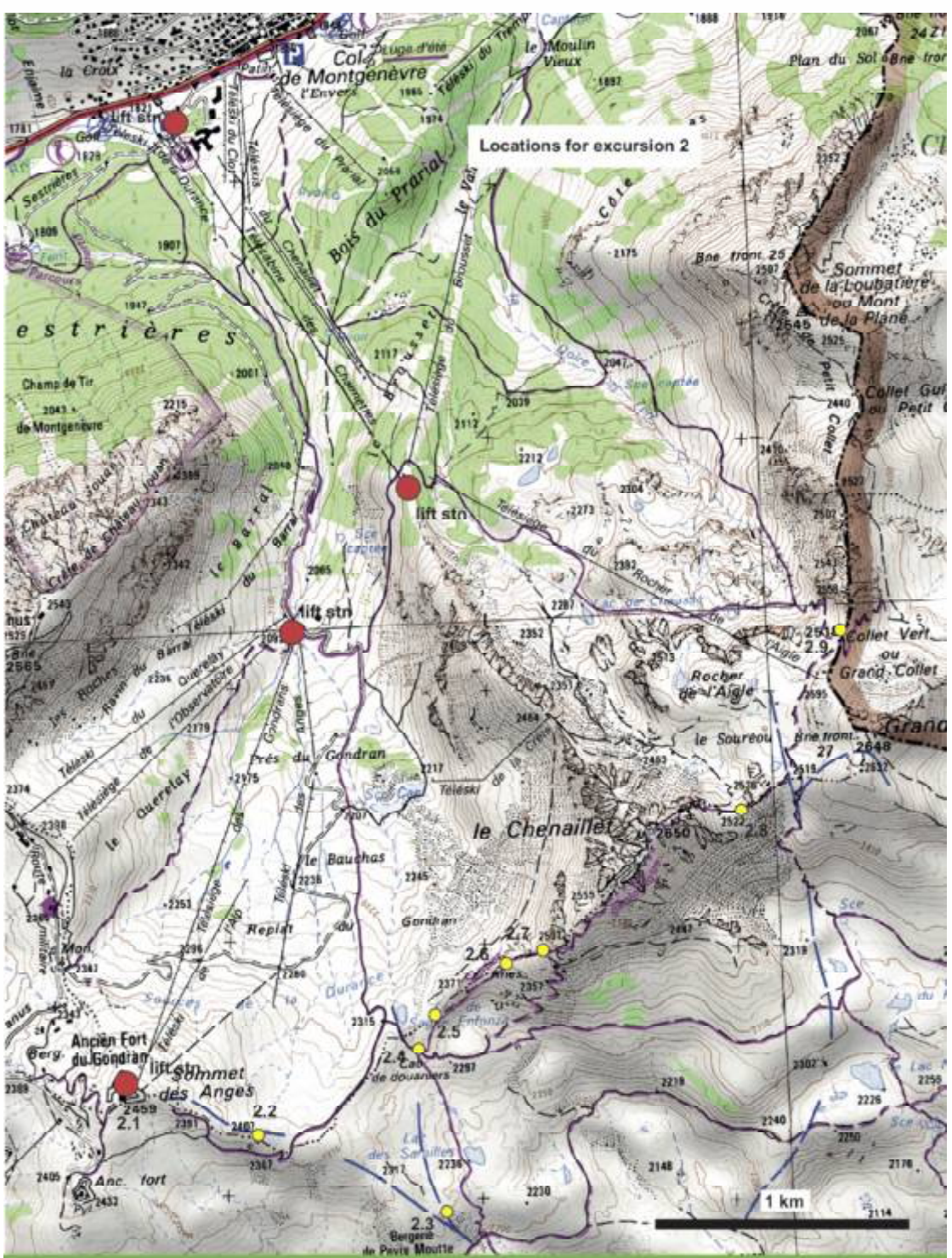
Serpentinites, ophicalcite overlain by pillow-breccia and hyaloclastites. Drop over the S side to see polygenic breccias.

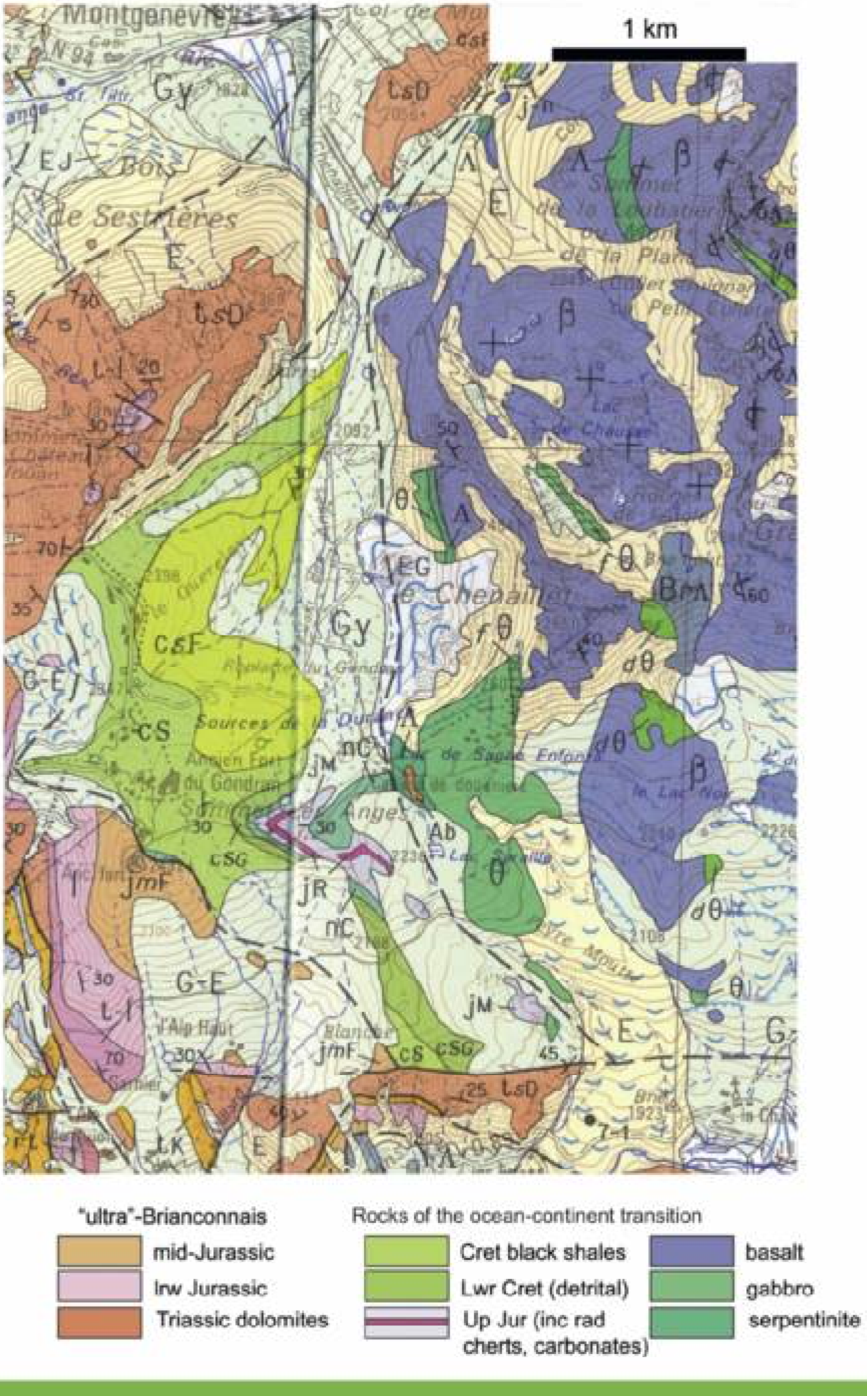
If there's time traverse across to Collet Vert - on the Italian border.

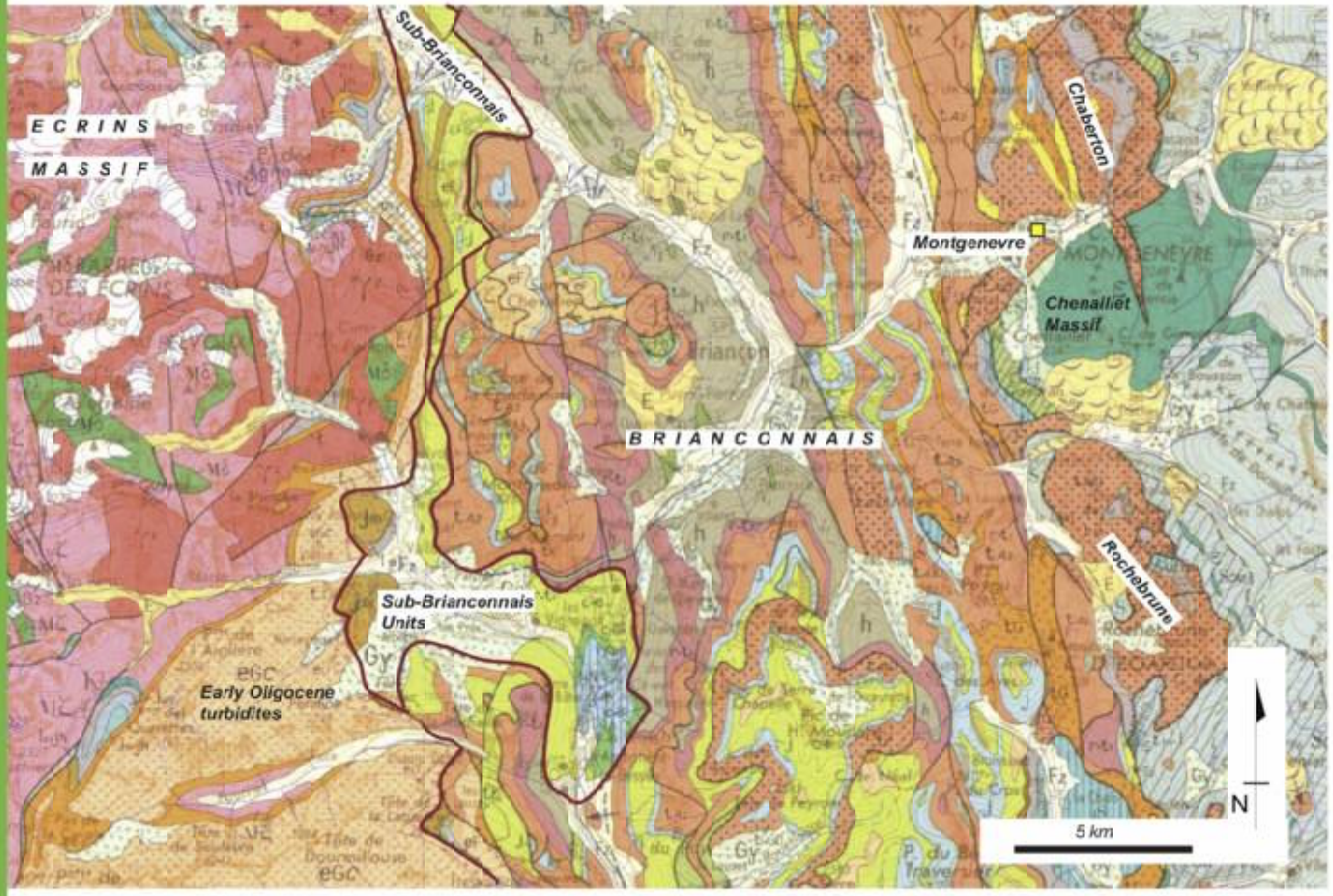
2.9 Pillow lavas

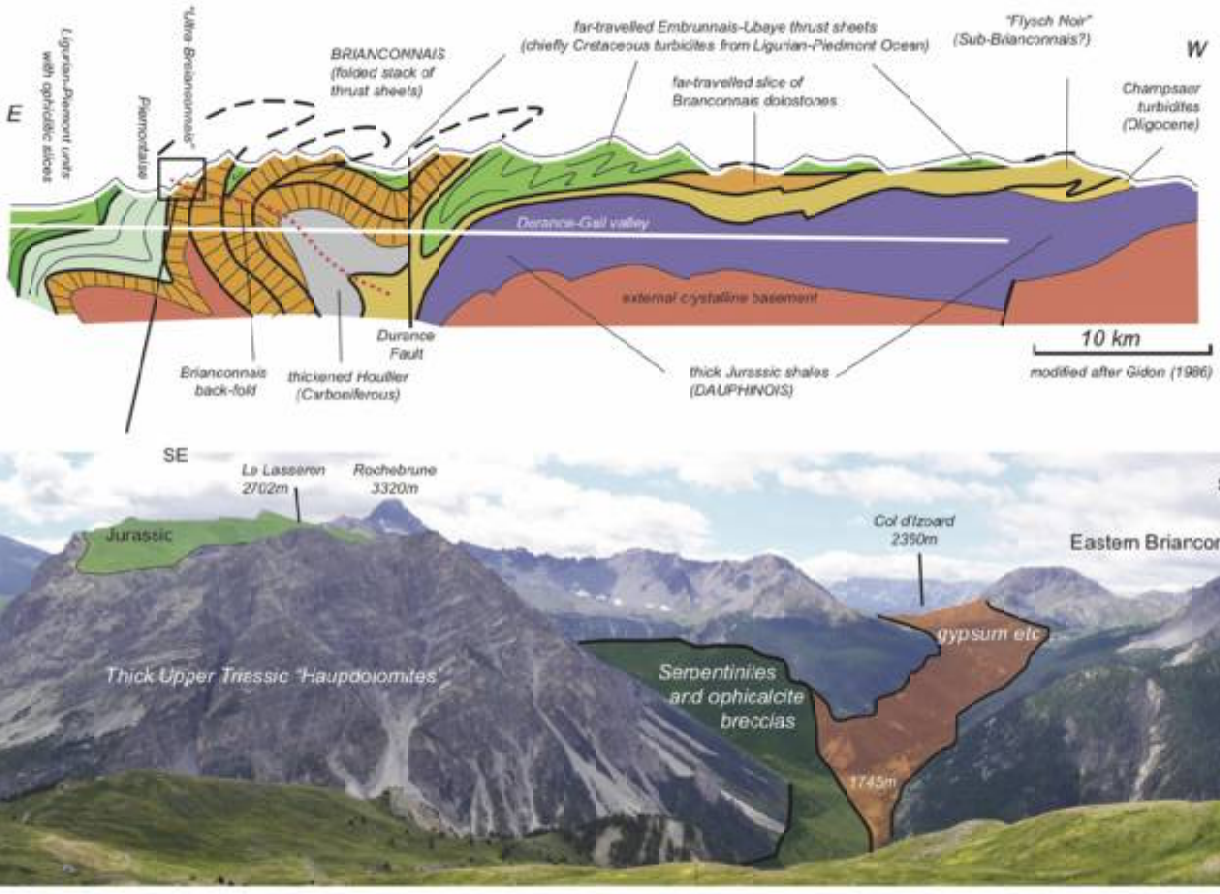
Vertical and photogenic.

Descend to the intermediate (gondola) lift - or if too late, descend to Montgenevre resort on foot.

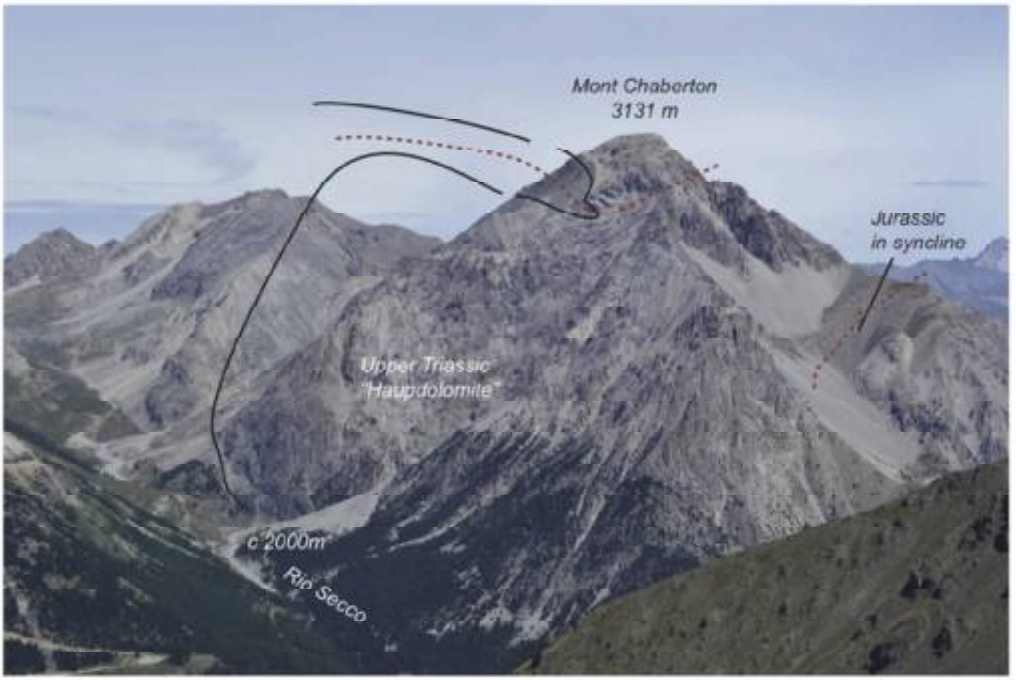

Locations for excursion 2
Col de Montgenèvre
l'Envers
le Moulin Vieux
Plan du Sol
Sommet de la Loubatière ou Mont de la Plane
Collet Vert ou Grand Collet
Rocher de l'Aigle
le Soureou
le Chenaillet
Ancien Fort du Gondran
lift stn
Sommet des Anges
Anc. fort
Bergerie de Petite Moutte
2.1
2.2
2.3
2.4
2.5
2.6
2.7
2.8
2.9
1 km


1 km
Montgenevre
Bois de Sestrières
Sources de la Durance
Ancien Fort du Gondran
"ultra"-Brianconnais
mid-Jurassic
lrw Jurassic
Triassic dolomites
Rocks of the ocean-continent transition
Cret black shales
Lwr Cret (detrital)
Up Jur (inc rad cherts, carbonates)
basalt
gabbro
serpentinite


ECRINS
MASSIF
Sub-Briançonnais
Chaberton
Montgenevre
Chenaillet
Massif
BRIANÇONNAIS
Rochebrune
Sub-Briançonnais
Units
Early Oligocene
turbidites
N
5 km

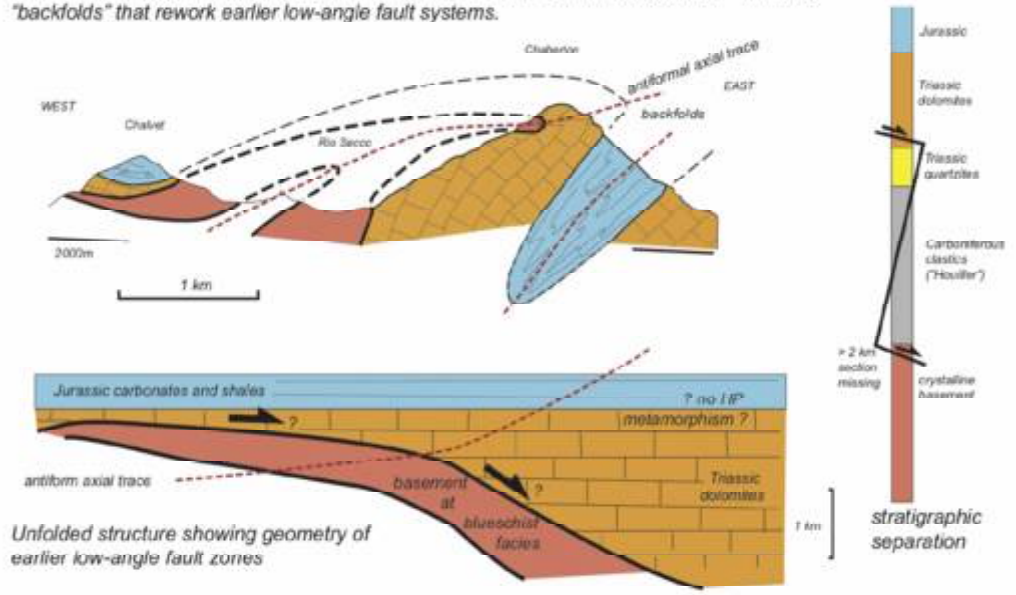


The view South onto the Rochebrune massif and surroundings - from the Sommet des Anges (2.1)



looking NNE towards M Chaberton from the Chenaillet massif

Interpretative cross-section through the hills to the North of Col du Montgenevre - showing "backfolds" that rework earlier low-angle fault systems.



Unfolded structure showing geometry of earlier low-angle fault zones

Gondran Series

The Gondran series are deep-water Jurassic sedimentary rocks. They are interpreted to represent strata deposited on either hyper-extended continental crust, the exhumed sub-continental mantle and/or newly-formed oceanic crust of Ligurian Tethys

NOTE: the section is isoclinally folded, and experienced blueschist facies metamorphism. The limestones (and inter-bedded meta-marls) display exceptional extensional crenulation cleavage.

Le Chenaillet seen from Le Janus

sheared gabbro cross-cut by epidosite (hydrothermal) veins

Oceanic detachment fault (or unconformity?)

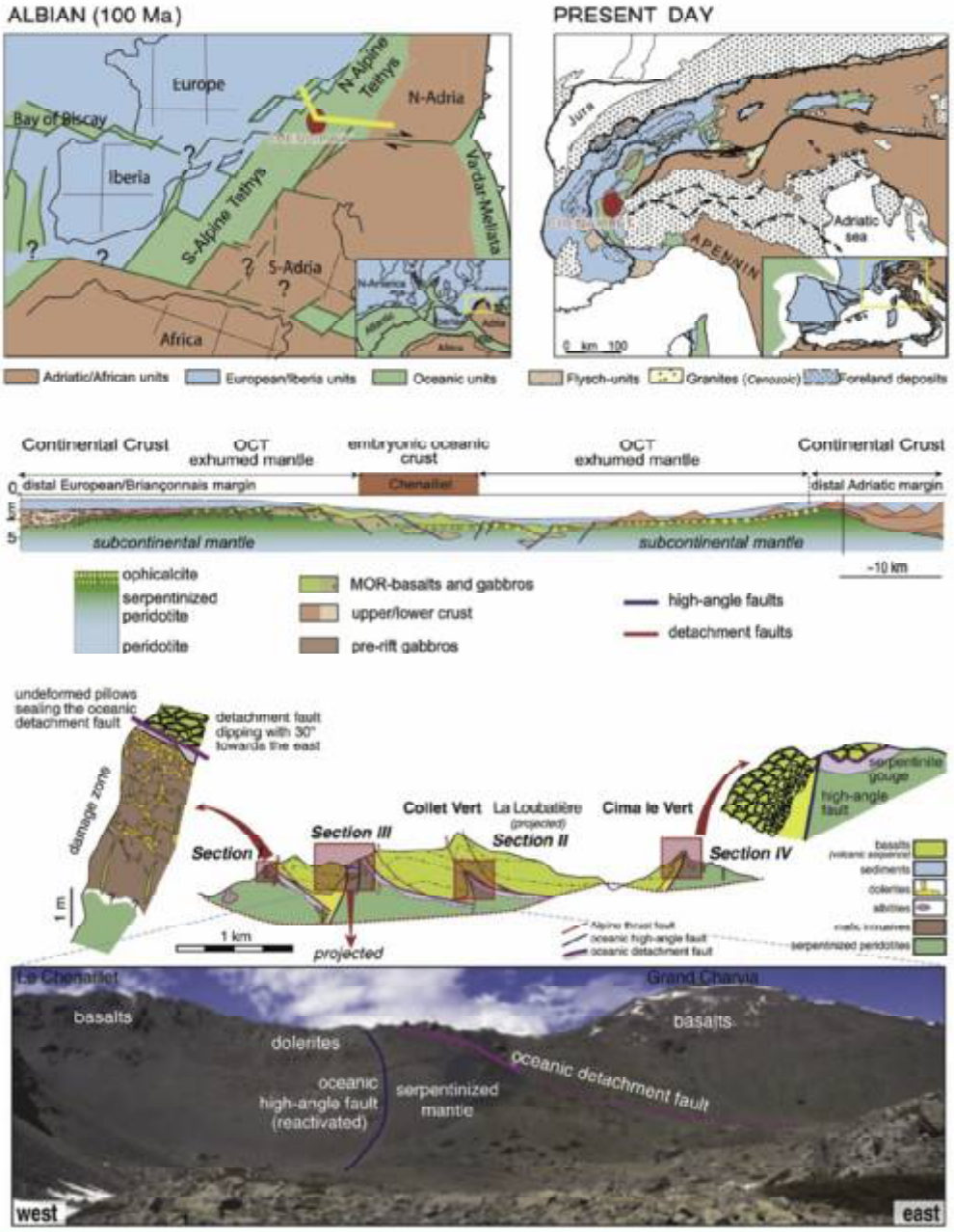
Outcrops on un-named col to E of Le Chenaifet with pillow breccias and hyaloclastites juxtaposed against serpentinites. This is a candidate exhumed detachment fault surface that brought serpentinite (hydrated sub-continental mantle) to the sea-bed.

Are the overlying basaltic debris deposited on this contact - or faulted against it? Outcrops on the steep S slopes of the col reveal polymict breccias - interpreted as fault scarp deposits or alternatively as hydrothermal vent breccias.

serpentinite breccias - ophicalcite at contact

polygenic breccias along contact

Diagrams from Manatschal et al. (2011, Lithos) illustrating their interpretations for the tectonic setting of the Chenaillet outcrops during Tethyan rifting (top set) and interpretations of outcrop geology - for discussion.



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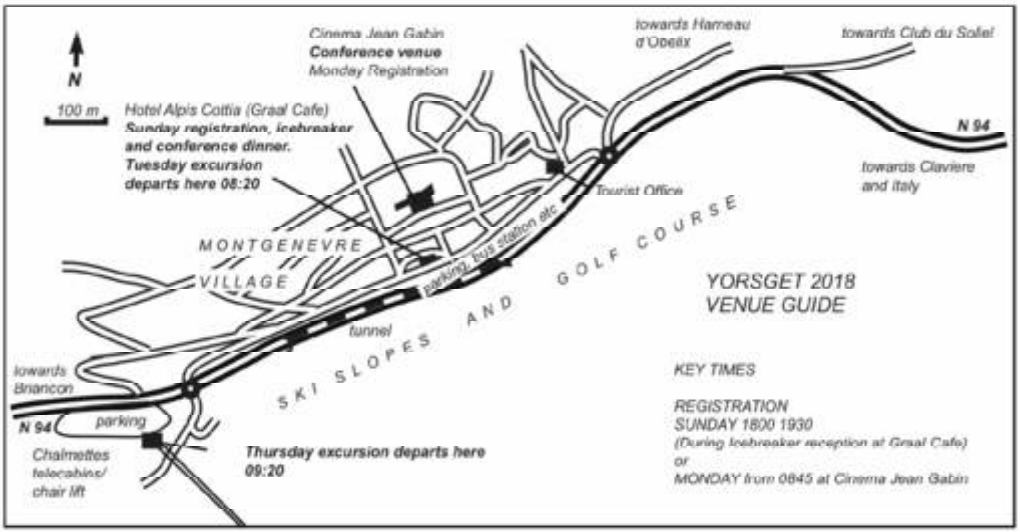

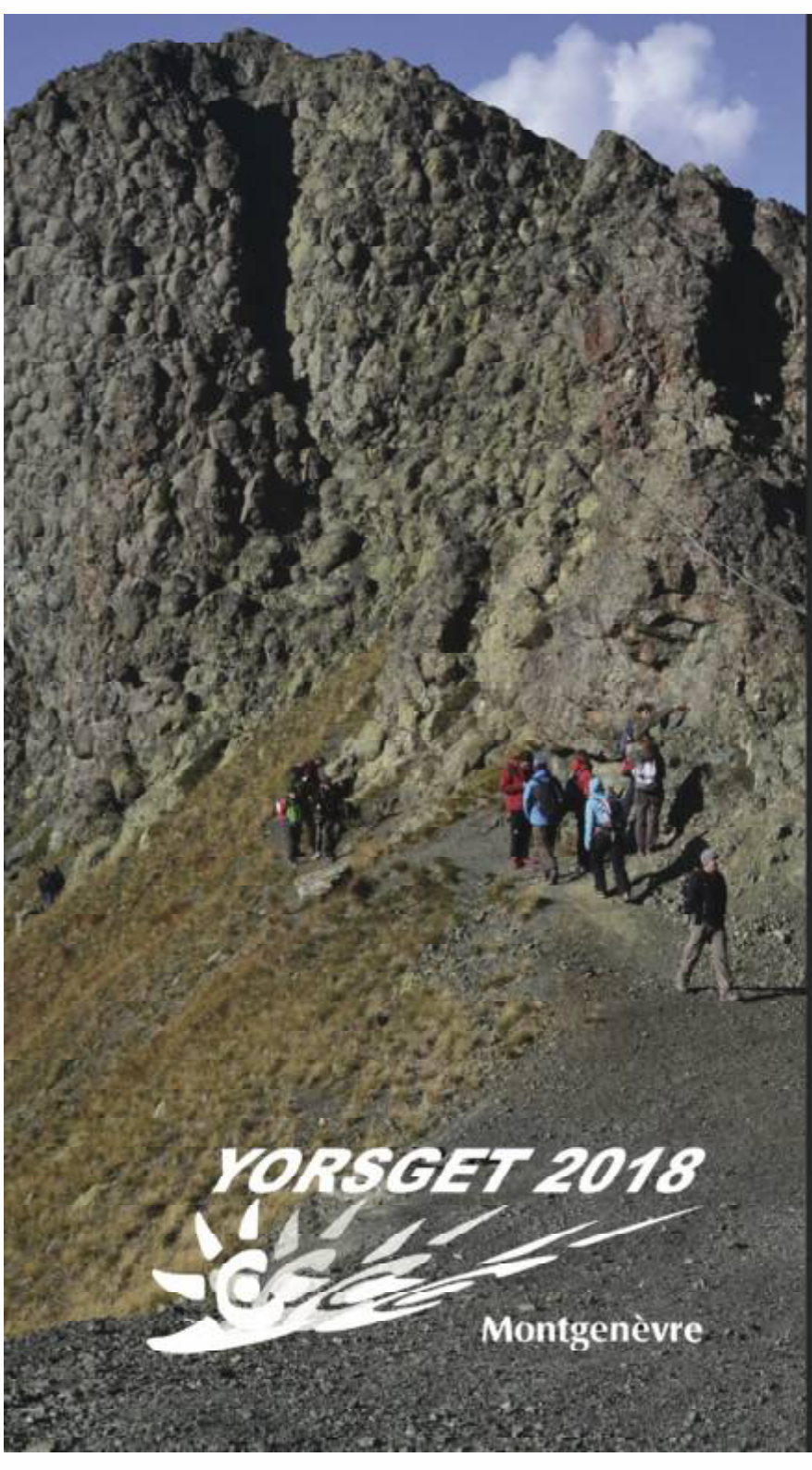

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