HIDROGEOLOGI KARST

Sari Bahagiarti Kusumayudha

UPN "VETERAN" YOGYAKARTA

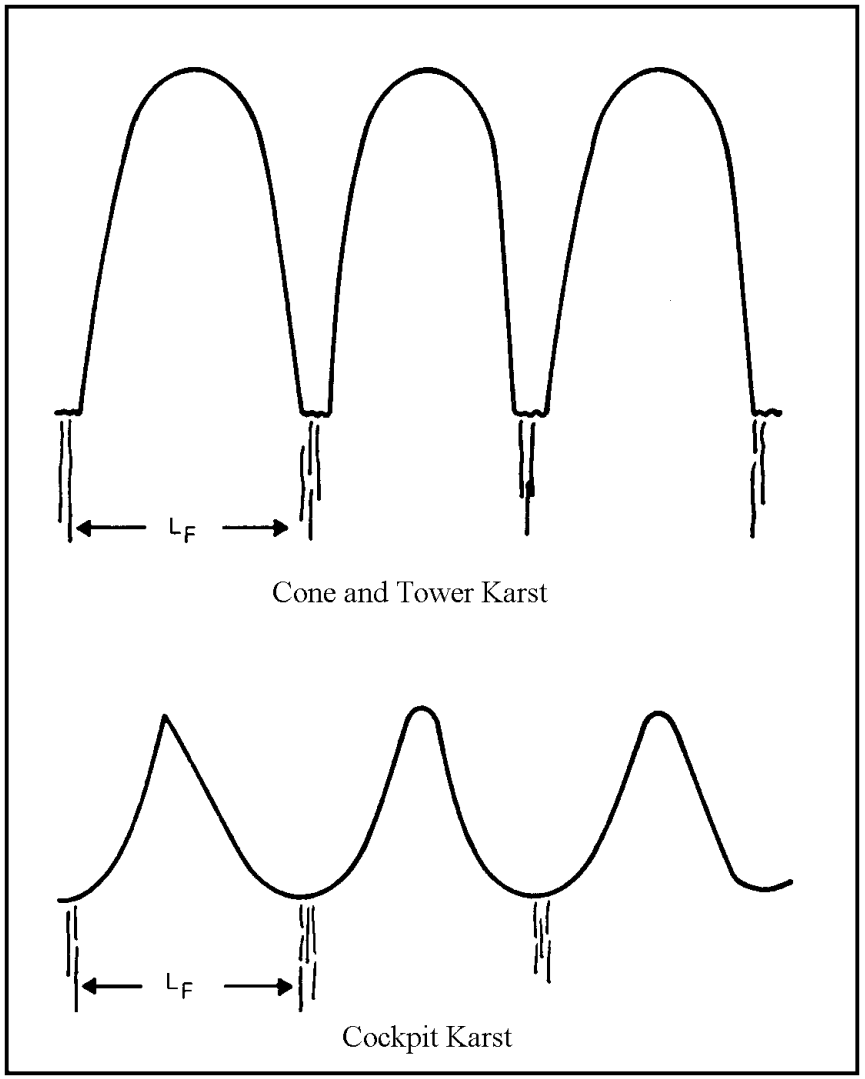
Karst:

- Morfologi: Suatu bentang alam, dicirikan adanya cekungan-cekungan tertutup hasil pelarutan, rongga-rongga, gua dengan segala ornamennya, dan sungai bawah tanah
- Hidrologi: Hasil interaksi antara batuan mudah larut dengan air meteorik, dicirikan adanya aliran melalui pembuluh/saluran (conduit flow), dan pengeringan bawah tanah

Geomorfologi Karst

- Eksokarst: morfologi karst yang terdapat di permukaan.
- Endokarst: morfologi karst yang terdapat di bawah permukaan.
- Morfologi Positif
- Morfologi Negatif

Morfologi Positif Karst



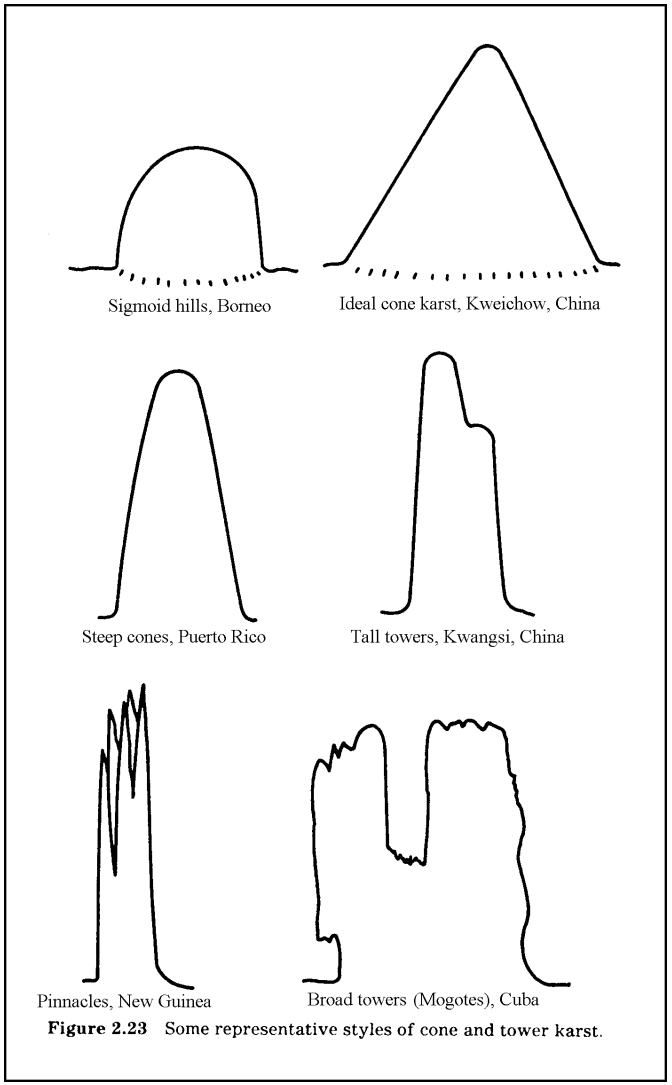
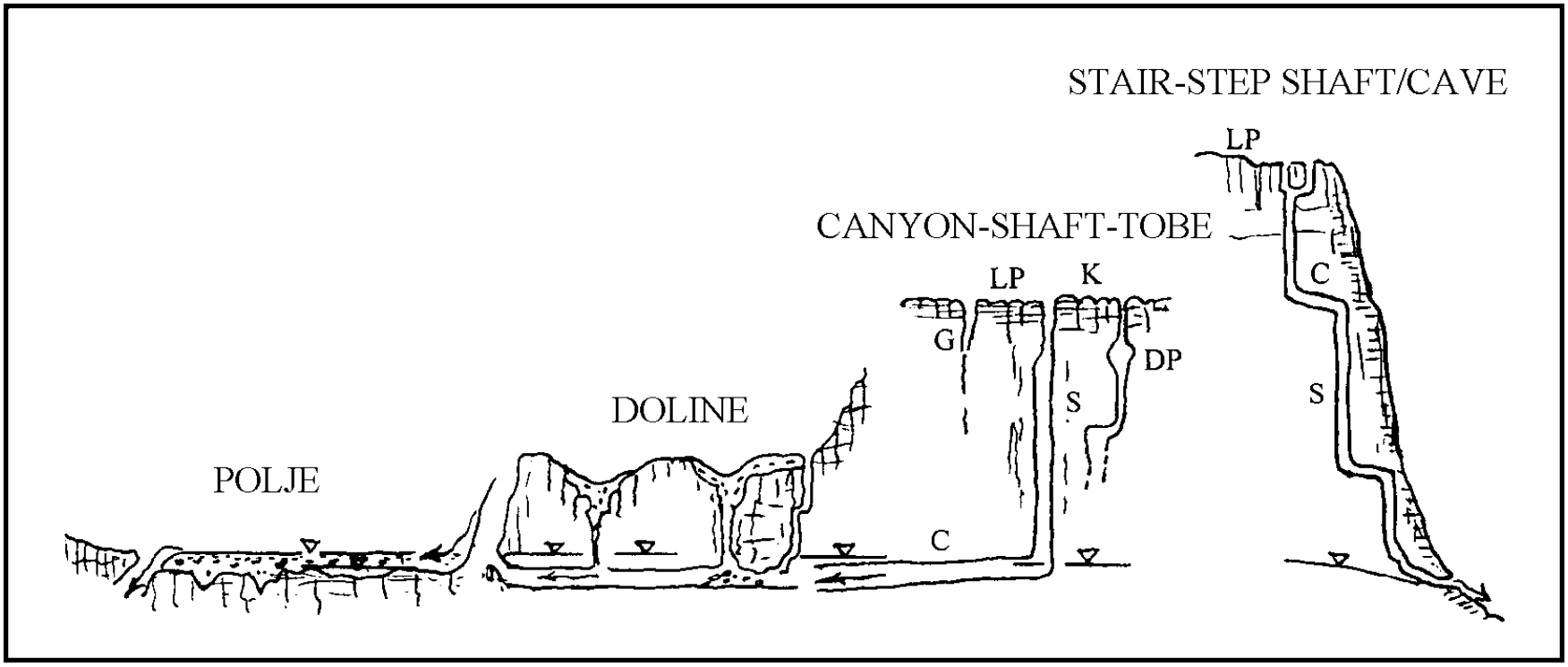
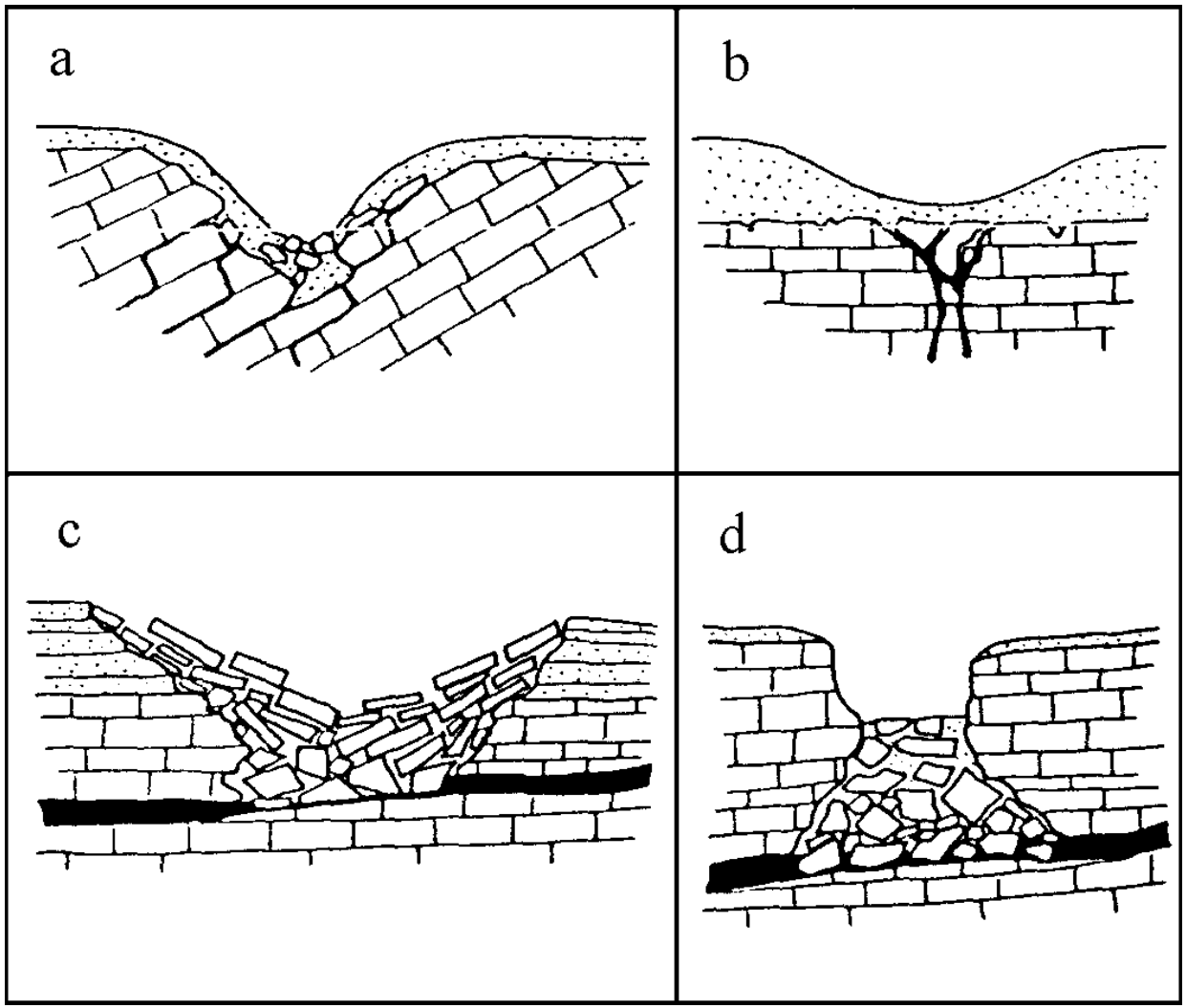


Figure 2.23 Some representative styles of cone and tower karst.

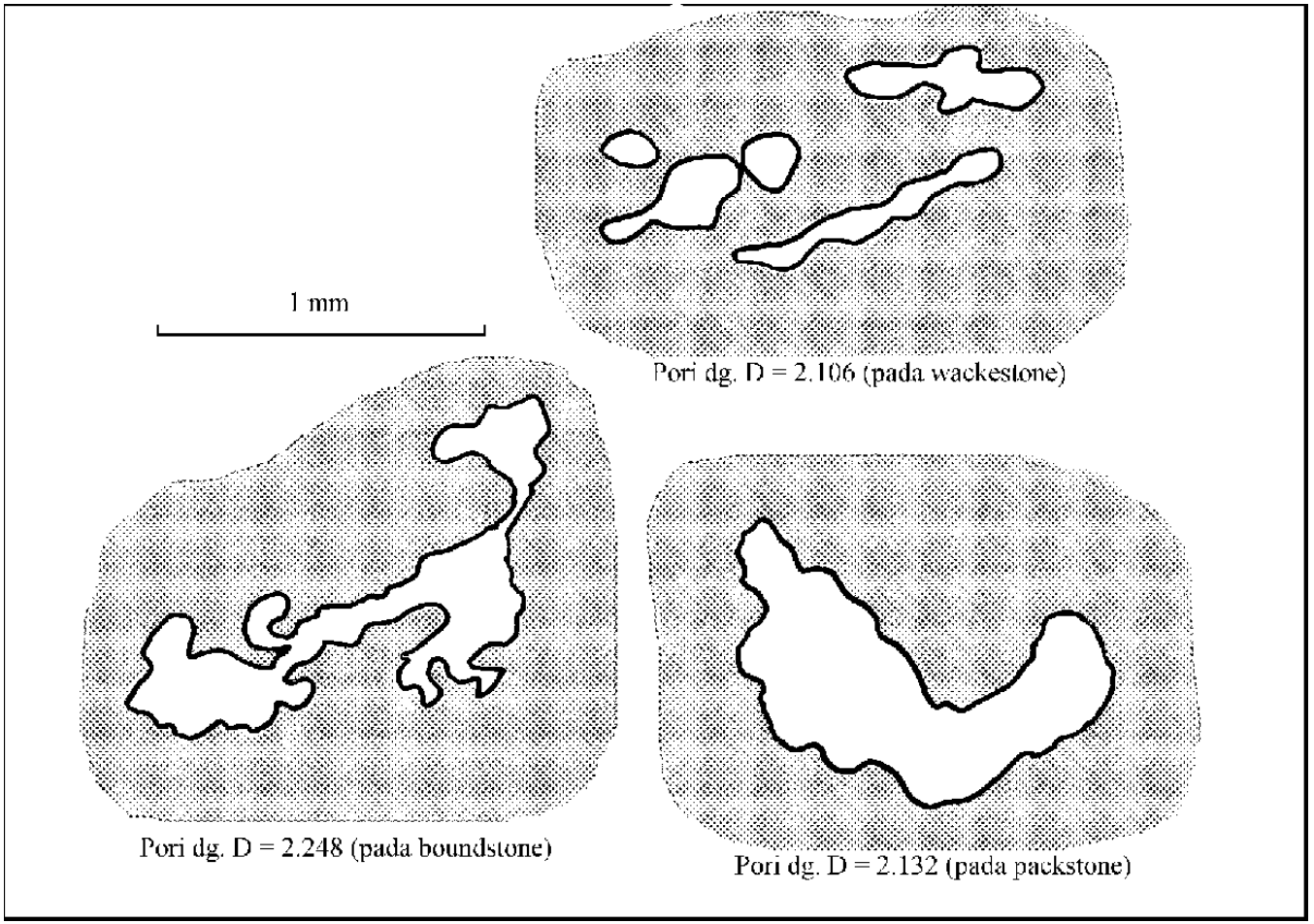
Morfologi Negatif



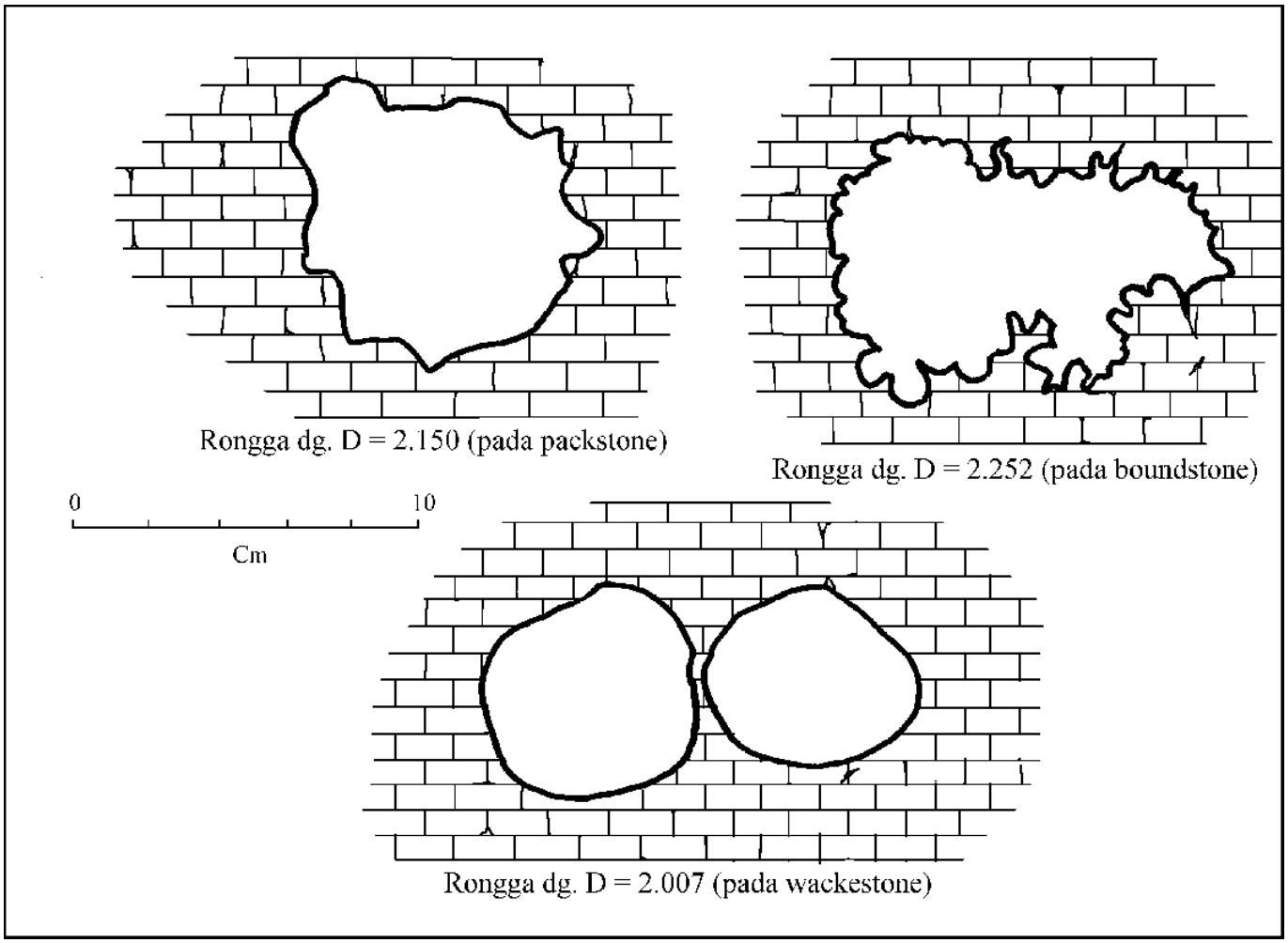
Struktur Dolina



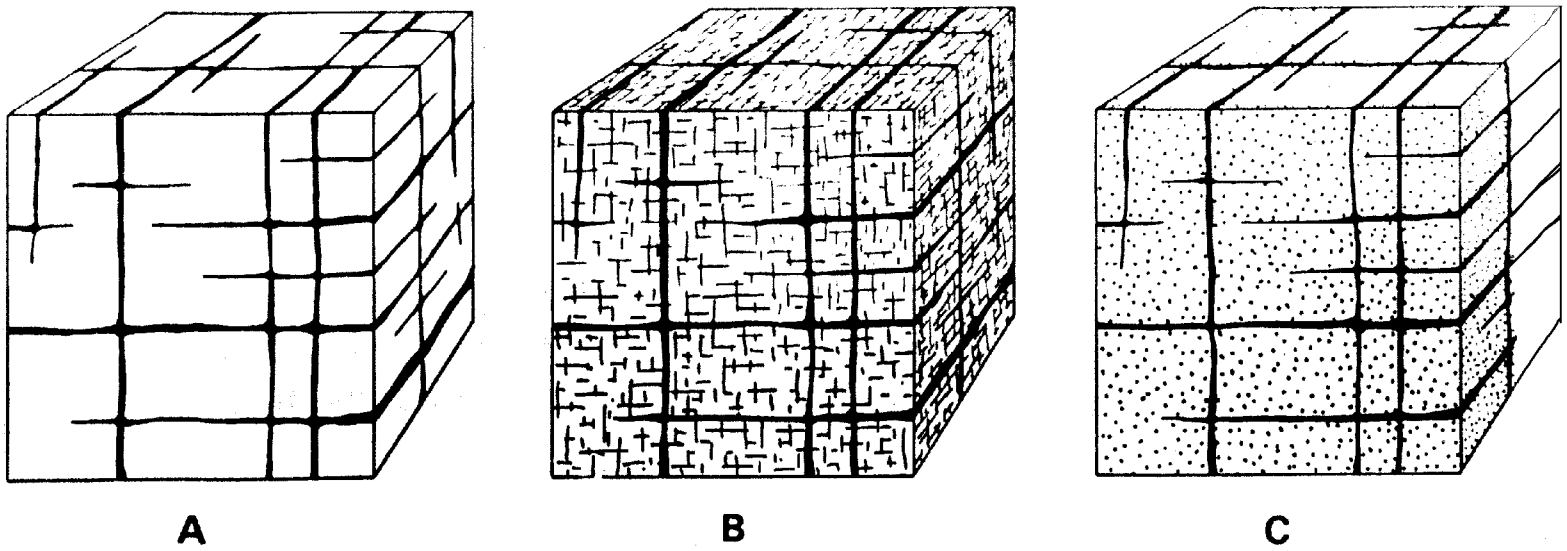
Bentuk Porositas Sekunder (mikroskopis)



Bentuk Rongga (megaskopis)



Model Porositas Batugamping

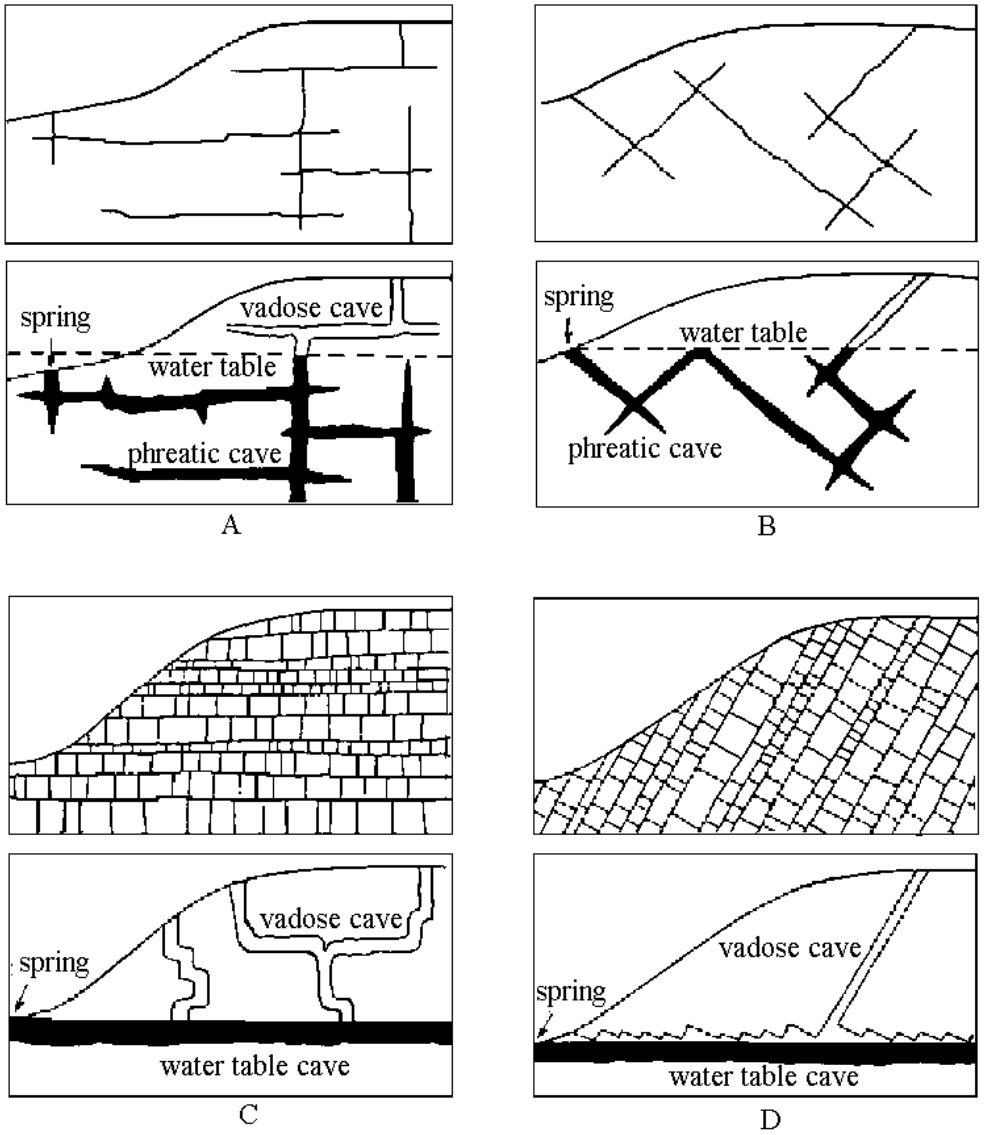


A. Retakan

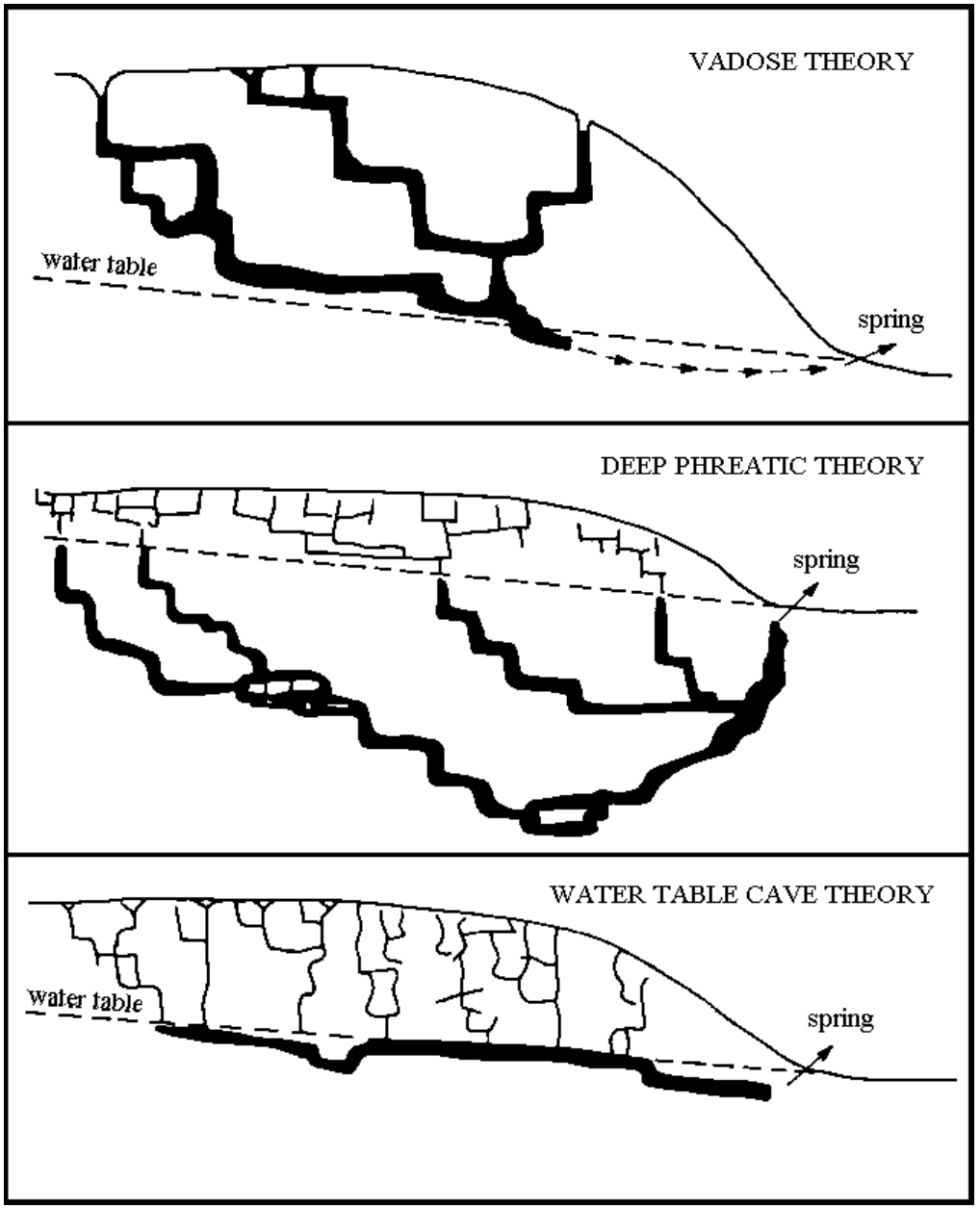
B. Retakan dan Pelarutan

C. Retakan dan Pori-pori antar Butiran

Pembentukan Saluran Bawah Tanah

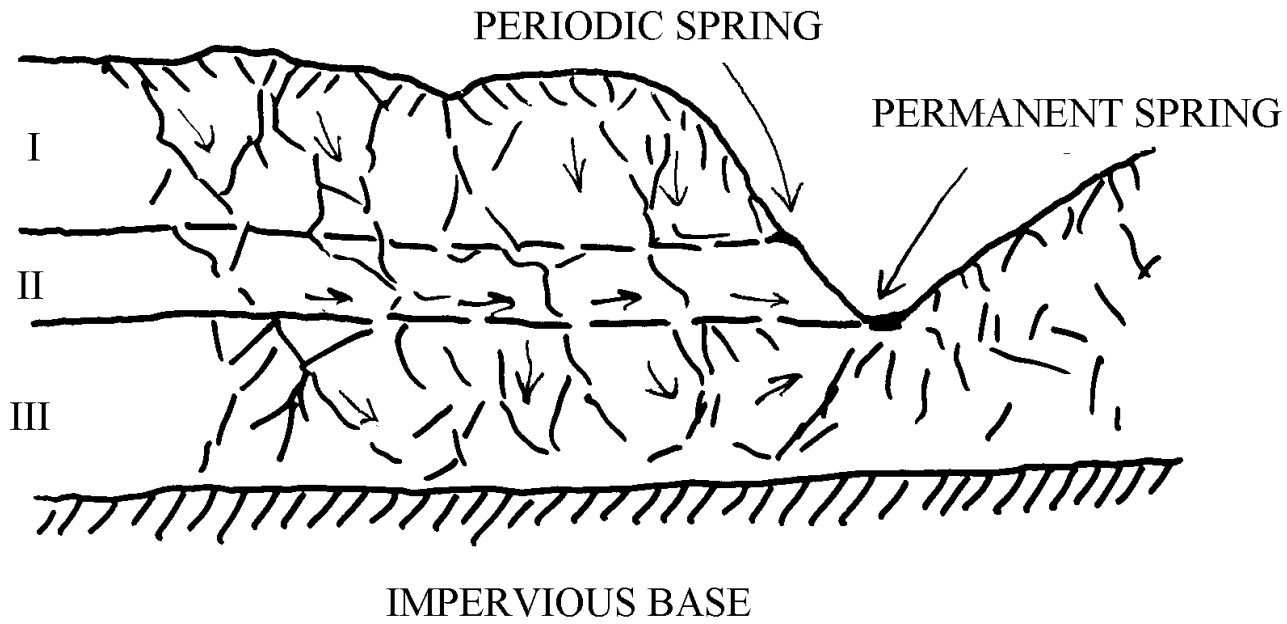


Teori Pembentukan Saluran Bawah Tanah

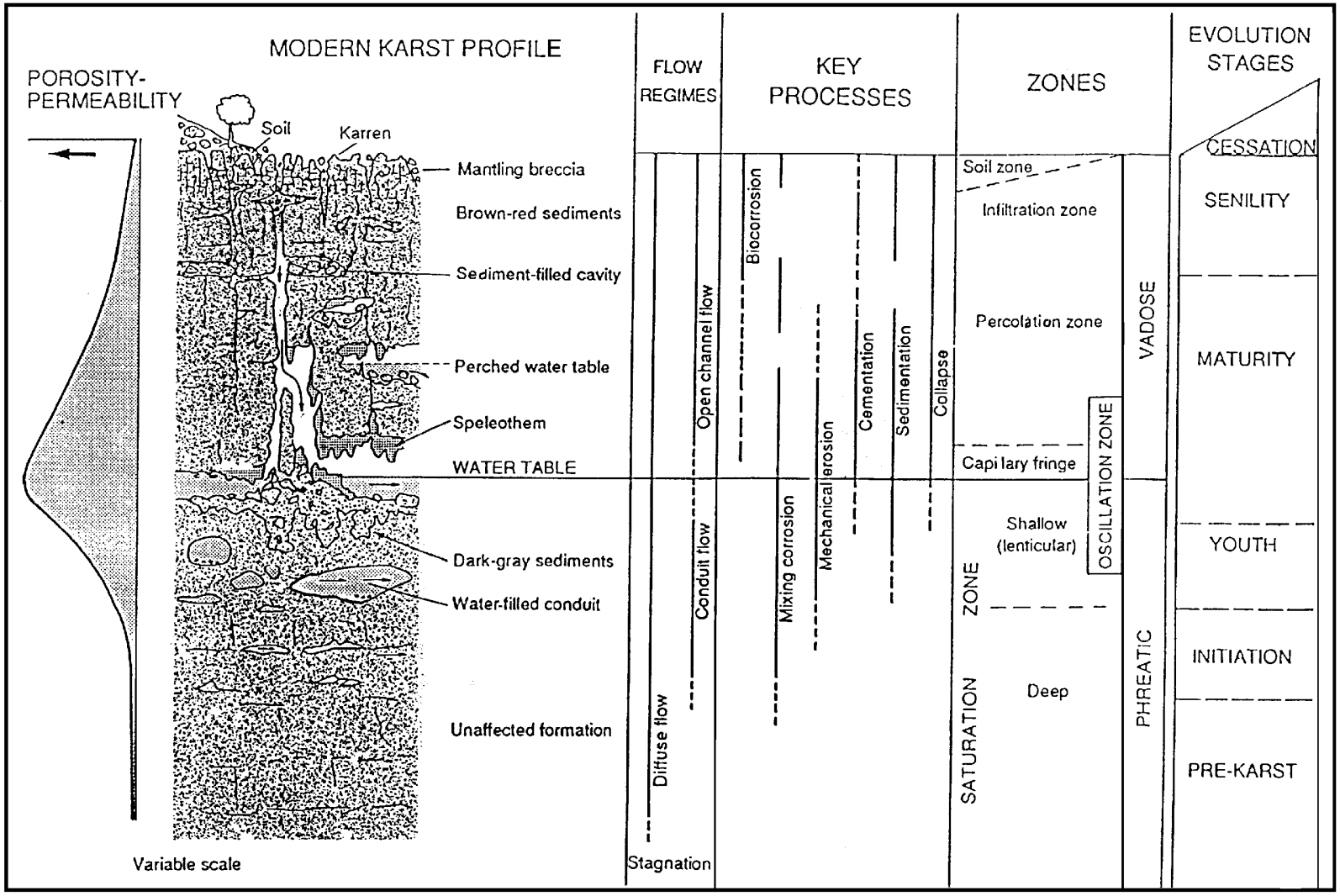


DISTRIBUSI VERTIKAL AIRTANAH PADA AKIFER KARS (CVIJIC, 1960)

I Dry Zone
II Trasition Zone
III Zone with permanent water flows

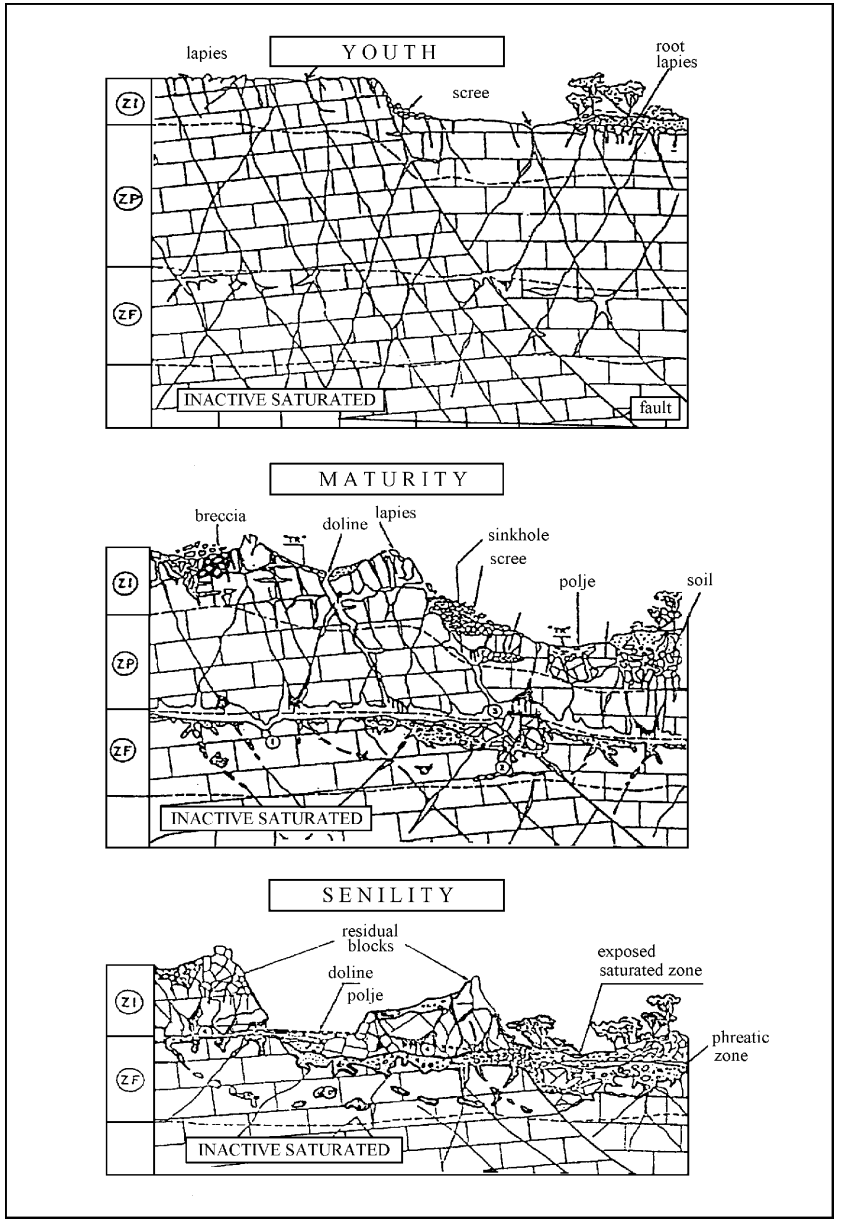


Profil Karst secara Vertikal



Vertical karst profile, showing stages of evolution and their relationship to porosity-permeability.

Stadium Karst (Esteban, 1996)



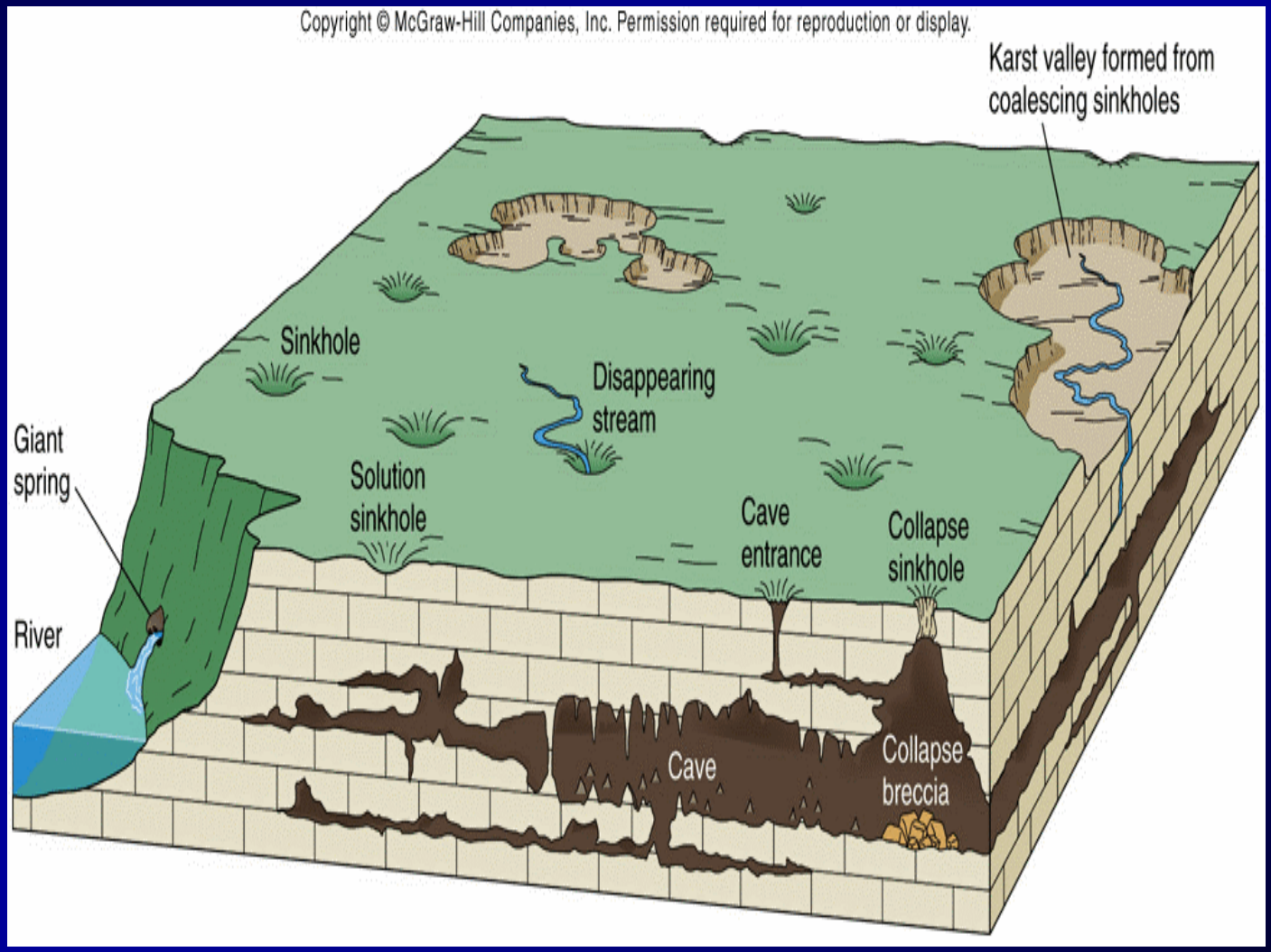
HIDROGEOLOGI KARST

- Lingkungan Fisik
- Sistem dan Karakteristik Akifer Kars
- Sistem Hidrogeologi
- Model Hidrogeologi
- Kualitas Airtanah
- Eksplorasi Airtanah
- Pengelolaan

LINGKUNGAN FISIK

- MORFOLOGI: TOPOGRAFI KARST
- LITOLOGI PENYUSUN: BATUGAMPING ATAU BATUAN KARBONAT LAINNYA
- SISTEM PENGERINGAN BAWAH PERMUKAAN

Lingkungan Fisik Karst



Kali Suci, alirannya masuk ke Gua Suci, selanjutnya mengalir di bawah permukaan

Karakteristik Sistem Hidrogeologi Karst

- Akuifer karst sangat sulit dieksploitasi, dikelola, dan dilindungi karena variabilitas ekstrem dari sifat hidroliknya yang hampir tidak mungkin ditentukan pada skala lokal.
- Fungsi hidrogeologisnya dipengaruhi oleh efek non-linearitas dan ambang batas.
- Mempertimbangkan eksploitasi akuifer jangka panjang, kompleksitas sistem karst tidak memungkinkan untuk pemodelan perilaku yang mudah, seperti menggunakan metode isochrone klasik untuk menentukan zona perlindungan.

- Karena akuifer karst dapat menawarkan kapasitas penyimpanan yang besar dan konduktivitas hidrolik lokal yang tinggi, laju aliran yang tinggi dapat dipompa dari lokasi tunggal, memungkinkan pengelolaan akuifer secara efektif.
- Setelah menguraikan karakteristik utama akuifer karst, pengelolaan air tanahnya dikaji dari sudut pandang kuantitas dan kualitas untuk menyoroti manfaat dan masalah daerah karst.
- Perlu terus dilakukan dan dikembangkan kajian-kajian dan penelitian-penelitian baru.

AKIFER KARST

- BATUAN PENYUSUN:
  - Berdasarkan Litofasies:
    - Batugamping terumbu: boundstone
    - Batugamping berlapis: packstone, wackestone, grainstone
    - Dolomit
  - Berdasarkan karakteristik fisik:
    - Batugamping karstik
    - Batugamping kalice

KARAKTERISTIK AKIFER

- BILA PENYUSUN AKIFER MERUPAKAN BATUGAMPING KARSTIK:
  - K, n, besar
  - Conduit flow
  - Hukum darcy tidak dapat diterapkan

- BILA PENYUSUN AKIFER MERUPAKAN BATUGAMPING KALICE:
  - K, n besar
  - Diffuse flow
  - Hukum Darcy berlaku

TIPE AKIFER

- Akifer Bebas
- Akifer Bertengger (Perched Aquifer)
- Akifer Tertekan

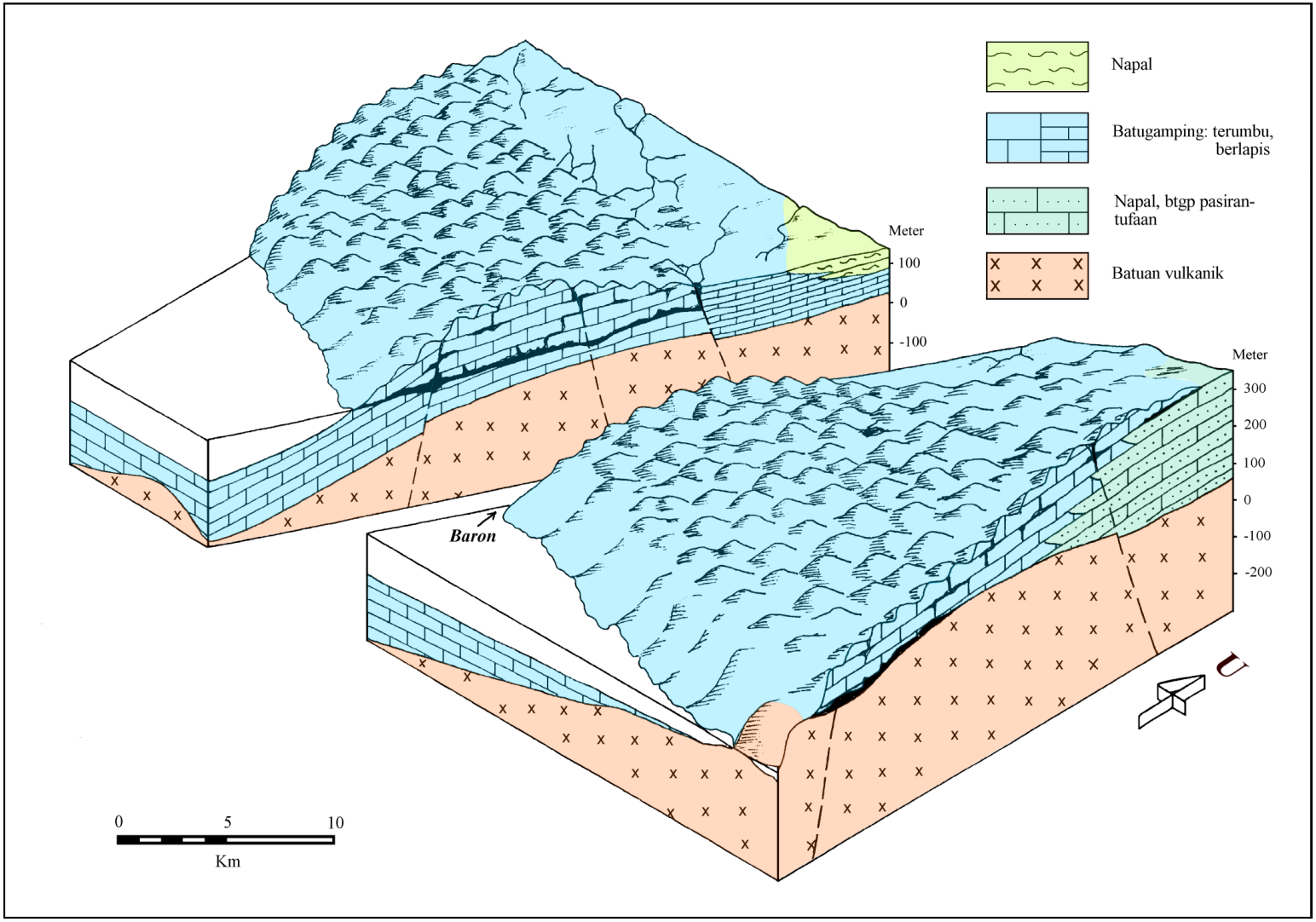
SISTEM AKIFER

- Lapisan Pembawa Air: Batugamping
- Batuan Alas (Bed Rock): Batuan vulkanik, batuan sedimen berbutir halus
- Lapisan Penyekat: napal

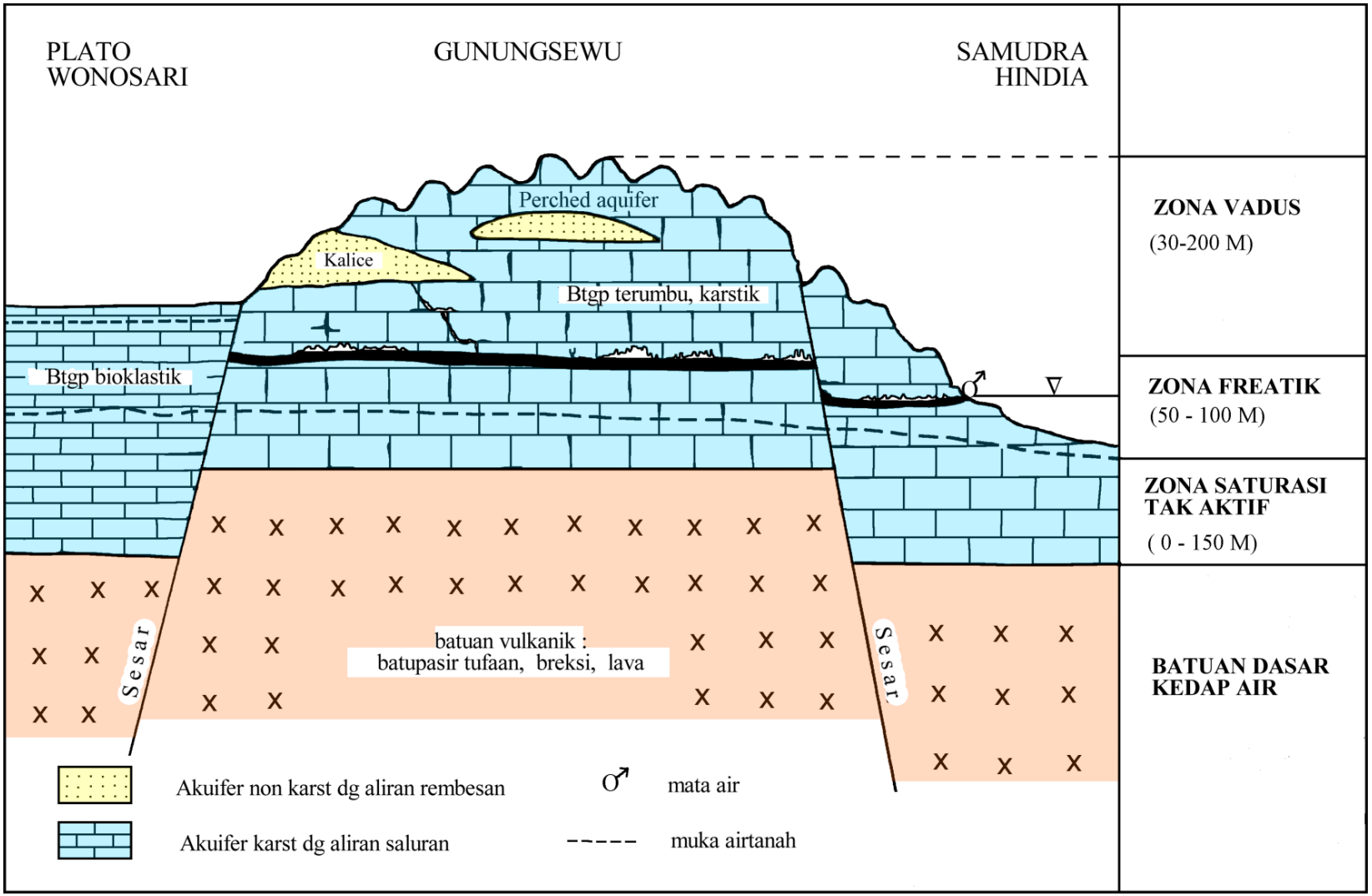
FLOW NET

- Garis Ekuipotensial: Tidak beraturan
- Garis Aliran: Tidak beraturan
- Flow net tidak valid

Geologi Karst Daerah Gunungsewu, Gunungkidul (Kusumayudha, 2000, 2005)



Model Hidrogeologi Konseptual daerah Gunungsewu, Sub-system Wonosari – Baron (Kusumayudha 2000, 2005)



Aliran sungai bawah tanah di Gua Bribin

Kualitas Airtanah Karst:

- Mengandung senyawa karbonat > airtanah non karst
- Kesadahan tinggi: sadah sampai dengan sangat sadah
- Rentan terhadap pencemaran: fisik, kimia, biologi

HIDROKIMIA

- DIPENGARUHI OLEH KOMPOSISI MINERAL BATUAN KARBONAT

  KATION: Ca, Mg, Na, K, Fe

  ANION: HCO_3, Cl, SO_4

POTENSI
(Buat Analisis SWOT)

- KEKUATAN:
  - Kualitas airtanah secara umum baik
  - Permeabilitas akifer besar
  - Banyak didapatkan mata air pantai
  - Banyak sungai di bawah permukaan
- KELEMAHAN: Sebaran tidak merata
- PELUANG: Pengembangan sungai bwh tanah
- ANCAMAN: Bencana Kekeringan

EKSPLORASI AIRTANAH

- PEMETAAN SEBARAN AKIFER
- PEMETAAN DISTRIBUSI SUNGAI BAWAH TANAH DAN MATA AIR
- PEMETAAN KUALITAS AIRTANAH
- PENGUKURAN DEBIT S.B.T.

METODE: SURVEI LAPANGAN, GEOFISIKA, ANALISIS GEOMETRI FRAKTAL

Kawasan Kars di Indonesia

- Kars Gunungsewu di DIY – Jateng
- Kars Gombong di Jawa Tengah
- Kars Tuban di Jawa Timur
- Kars Maros di Sulawesi Selatan
- Kars Wawolesea di Sulawesi Tenggara
- Kars Jaya-Wijaya di Papua
- Kars di Nusatenggara, Halmahera, Morotai, Biak

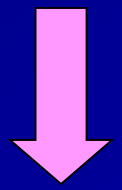
Tipe Gunungsewu

- Terdiri dari ribuan bukit/kubah
- Aliran permukaan menyusup ke bawah permukaan
- Rongga-rongga dikontrol oleh kekar
- Banyak sungai bawah tanah, potensi air melimpah
- Luahan ke samudra melalui muara

Conical Karst di Daerah Paliyan, dan Dome Karst di Daerah Ponjong,Gunungkidul

Pantai Ngungap, Gunungkidul

Tipe Gombong



- Batugampingnya tipis
- Mata air kontak antara btgp dg batuan vulkanik di bawahnya
- Membentuk aliran permukaan di daerah bukan kars

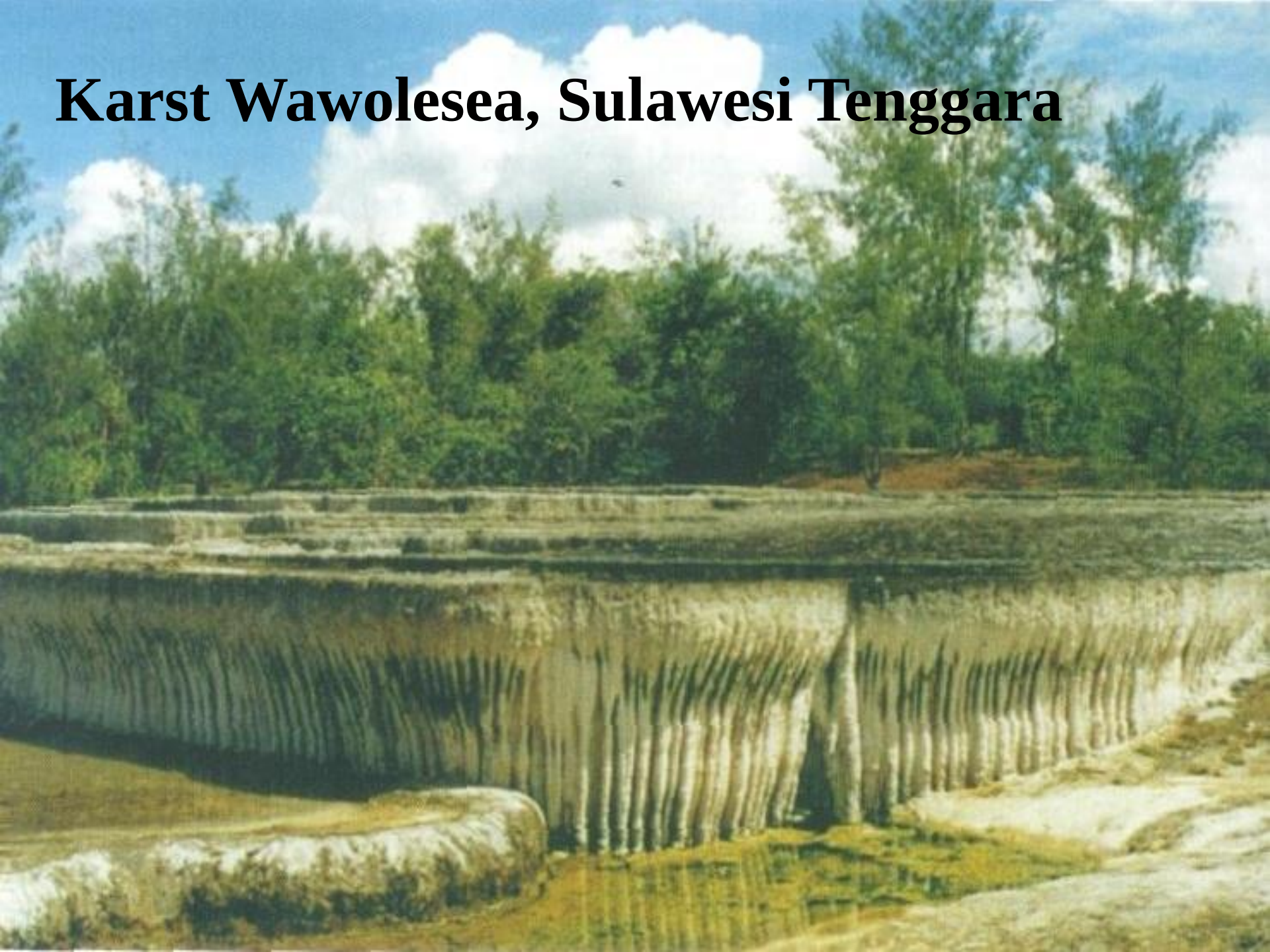
Karst Gombong

Tower Karst di Maros, Sulawesi Selatan

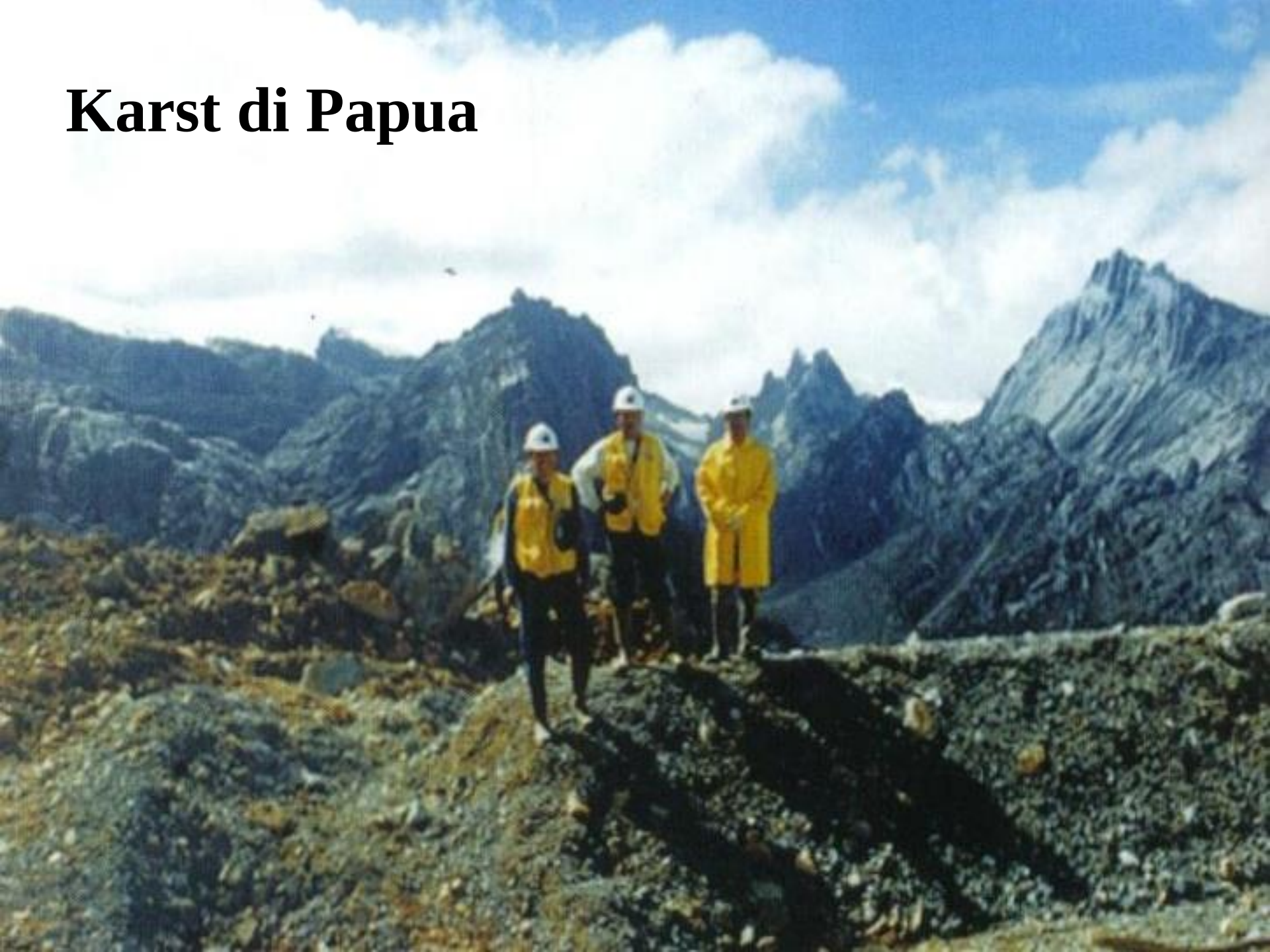
Tipe Wawolesea

- Unik, dikendalikan oleh air panas dan air asin
- Temperatur air panas di daerah ini berkisar 35^{o} - 45^{o}
- Pada saat pasang, air laut mendesak ke darat melalui sistem lorong gua, menyebabkan air menjadi asin

Karst Wawolesea, Sulawesi Tenggara



Karst di Papua



PENGELOLAAN

- PERTAHANKAN LUAS DAERAH RESAPAN
- PERTAHANKAN PERMEABILITAS AKIFER
- PEMANFAATAN DAN PENGEMBANGAN AKSES SUNGAI BAWAH TANAH
- PEMANFAATAN MATA AIR / MUARA SUNGAI BAWAH TANAH
- HINDARI PENCEMARAN DI DAERAH PONOR
- PEMBUATAN ARTIFICIAL RESERVOIR
- DIDUKUNG KEBIJAKAN/PERATURAN

Karst Groundwater Management

- Water resources management schemes generally imply the availability of a spectrum of various sources of water with a variability of quantity and quality in space and time, and the availability and suitability of storage facilities to cover various demands of water consumers on quantity and quality.
- Aquifers are generally regarded as suitable reservoirs since large volumes of water can be stored in the subsurface, water is protected from contamination and evaporation and the underground passage assists in the removal of at least some groundwater contaminants.

Karst Groundwater Management

- Favorable aquifer properties include high vertical hydraulic conductivities for infiltration, large storage coefficients and not too large hydraulic gradients / conductivities. The latter factors determine the degree of discharge, i.e. loss of groundwater.
- Considering the above criteria, fractured and karstified aquifers appear to not really fulfill the respective conditions for storage reservoirs.
- Although infiltration capacity is relatively high, due to low storativity and high hydraulic conductivities, the small quantity of water stored is rapidly discharged.

Karst Groundwater Management

- However, for a number of specific conditions, even karst aquifers are suitable for groundwater management schemes.
- They can be subdivided into active and passive management strategies. Active management options include strategies such as overpumping, i.e. the depletion of the karst water resources below the spring outflow level, the construction of subsurface dams to prevent rapid discharge.
- Passive management options include the optimal use of the discharging groundwater under natural discharge conditions.

Karst Groundwater Management

- System models that include the superposition of the effect of the different compartments soil zone, epikarst, vadose and phreatic zone assist in the optimal usage of the available groundwater resources, while taking into account the different water reservoirs.
- The elaboration and implementation of groundwater protection schemes employing well established vulnerability assessment techniques ascertain the respective groundwater quality.

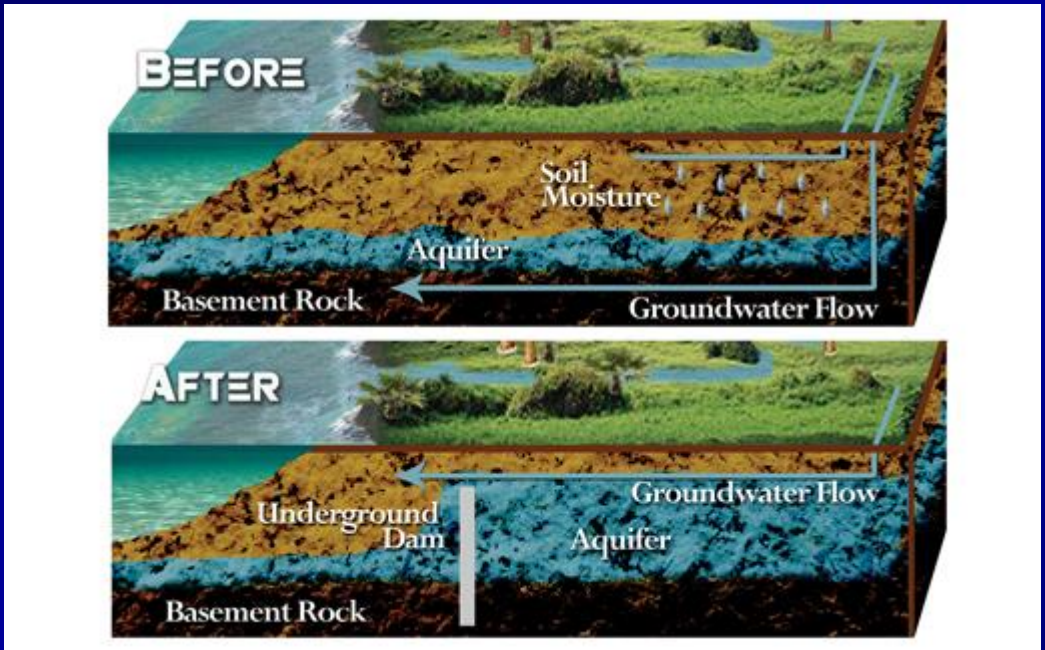
- A systematic overview should be provided on karst groundwater management schemes illustrating the specific conditions allowing active or passive management in the first place as well as the employment of various types of adapted models for the design of the different management schemes.

Karst Water Management

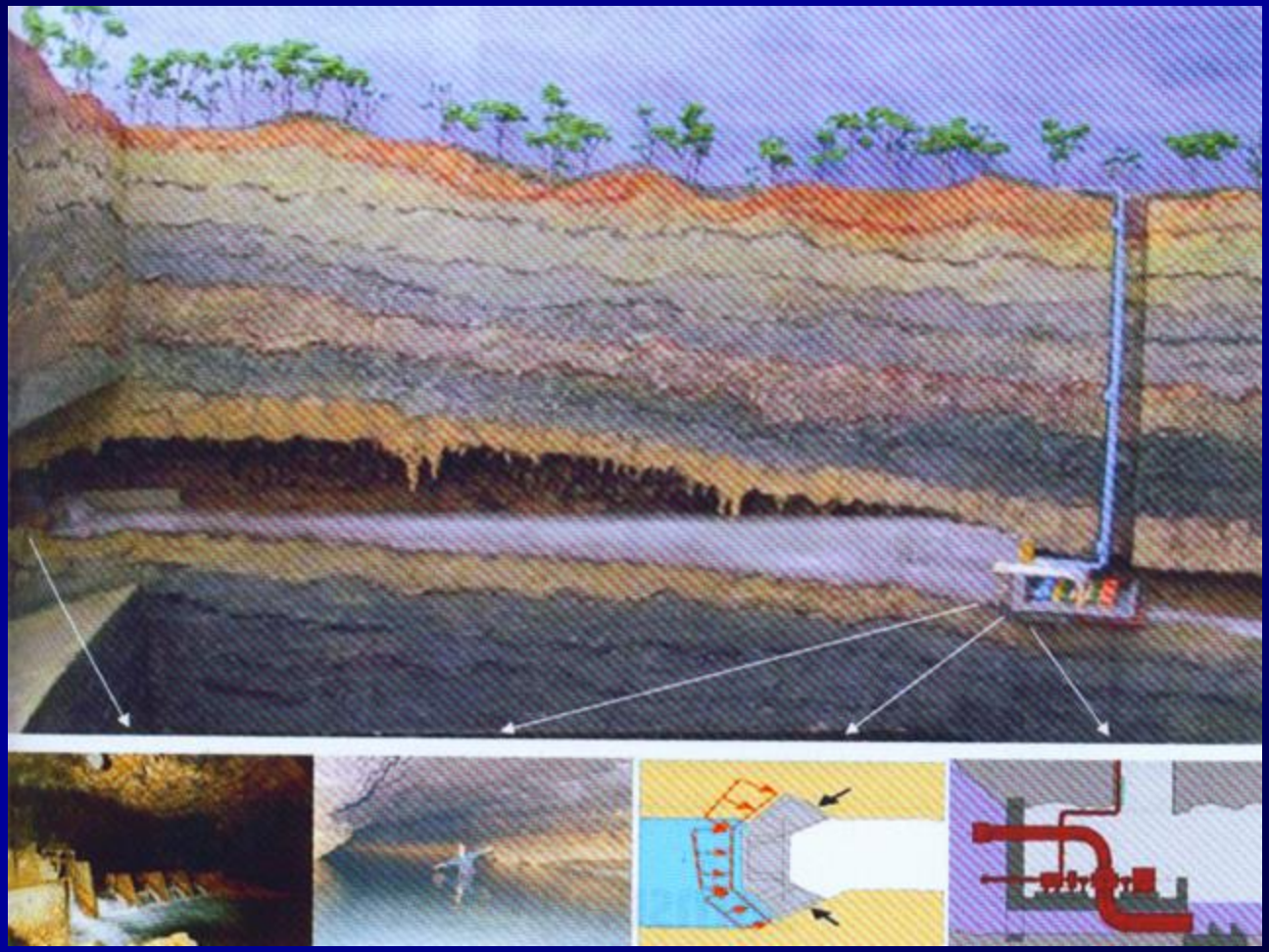
- Examples are provided from karst systems in Israel/Palestine, where a large 4000sqkm basin is being managed as a whole, the South of France, where the Lez groundwater development scheme illustrates the optimal use of overpumping from the conduit system, providing additional water for the City of Montpellier during dry summers and at the same time increasing recharge and assisting in the mitigation of flooding during high winter discharge conditions.

- Overpumping could be an option in many Mediterranean karst catchments since karst conduit development occurred well below today's spring discharge level.
- Other examples include the construction of subsurface dams for hydropower generation in the Dinaric karst and reduction of discharge. Problems of leakage and general feasibility are discussed.

Undergrround Dam



Pembangunan pembangkit listrik mikrohidro di Gua Bribin



SEKIAN

TERIMAKASIH