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مقرر عملي الجيولوجيا التركيبية

لطلاب الفرقة الثالثة

جميع الشعب

الفصل الدراسي الأول

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Geology Department

Structural Geology Laboratory Manual

for 3rd Year Students

by

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Introduction

This highly illustrated student guide introduces the skills of interpreting a geological map and relating it to the morphology of the most important types of geological structure. Thoroughly revised, and with more international examples, it is ideal for use by students with a minimum of tutorial supervision.

What is a Geologic Map?

A geologic map is a map that provides extensive information about the geology or geologic features of an area of land. Geologic maps show the types of rock and geological formations found in a land area. Geologic maps may include the locations of rocks, deposits, types of soil, dikes, faults, and folds. Dikes are massive rocks that slice through another kind of rock. Faults are fractures or areas where masses of rock have moved. A fold is a wavelike bend in a rock formation that occurs because of the warping of stratified rocks over time. Geologic maps use many colors to show the placement of various geologic features.

Geologic maps are an extremely valuable source of information for obtaining geologic information regarding land areas. They may be referenced for projects involving geohazards, land development, and waste allocation. These maps are also useful in the management of water, mineral, and energy resources. Current geologic maps are often digital resources.

Geologic maps differ from topographical maps, which use elevation contour lines to convey information about the land. Topographical maps provide information about the three-dimensional form of the land and portray the land's overall shape. Geologic maps provide information specific to the land's geology, including the area's surface and subterranean features. Geologic maps also use color to indicate geologic units.

How to Read a Geologic Map

Reading a geologic map requires an understanding of what a geologic map shows and how the information is conveyed. The colors, letter symbols, and lines used in geologic maps all provide significant information.

The colors of a geologic map:

- Each designates a distinct geologic unit.
- Mark the spread of a specific type of rock. Igneous rock areas are often depicted in darker colors, while sedimentary rocks are often depicted in lighter colors.
- Make a geologic map more user-friendly and appealing.
- Are often inspired by a formal system of colors and patterns. The United States Geologic Survey (USGS) published an initial set of recommendations for the use of colors in 1881. The standards within the USGS compendium have changed over time. There is also an "International color system" that was put forth in Europe shortly after the USGS standards were published. It is advised that these sets of standards be considered when creating a geologic map. However, they are not so rigid that the colors and patterns of every map are the same. For example, one standard may advise that lavender or neutral colors mark the Devonian age with lines in magenta or cyan.

The letter sequences on a geologic map:

- Are used to indicate the age of the geologic unit. The first capitalized letter references a specific geologic age. For example, the symbol T references the Tertiary period, which spans from 66 to 2.6 million years ago. Several geologic ages begin with the same letter, and in these cases, an alternate letter or symbol is used. These letters include C and P. Because the Cenozoic, Carboniferous, and Cambrian geologic ages cannot all be indicated by the letter C, others are used.

- Are also used to show the type of rock. These characters are found after the first capitalized letter.

The lines on a geologic map:

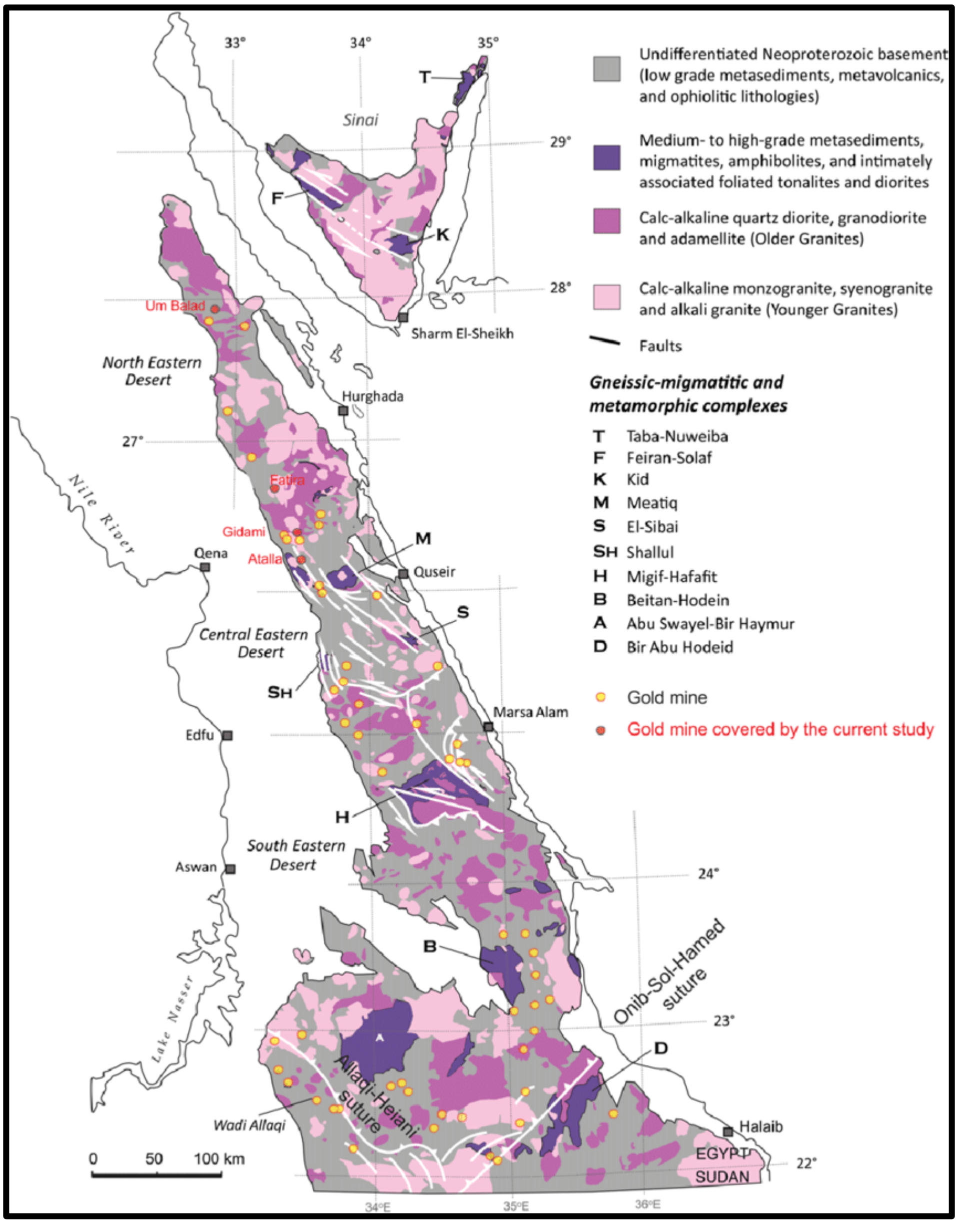
- Provide information about the locations of geologic contacts, faults, folds, and fractures.
- Show where two units of rock formation contact one another.
- Are often thin to indicate contacts and thick to show faults.
- Are dotted or dashed in areas where there is uncertainty.

Understanding Geological Maps with Keys

- A **map key**, also sometimes called a legend, is a table of the symbols used within the map and their definitions. A map key clarifies what the symbols on the map mean. Without map keys, users would have much more difficulty understanding geological maps. For example, a map key may indicate that a thin, solid line denotes a known fault with a known location. The key may also show that a thin, solid line with a question mark denotes an uncertain fault with a known location. The question mark tells the reader that the presence of the fault has not been confirmed.
- The geologic map symbols included in a key are specific to a geologic area. There are many symbols used on geologic

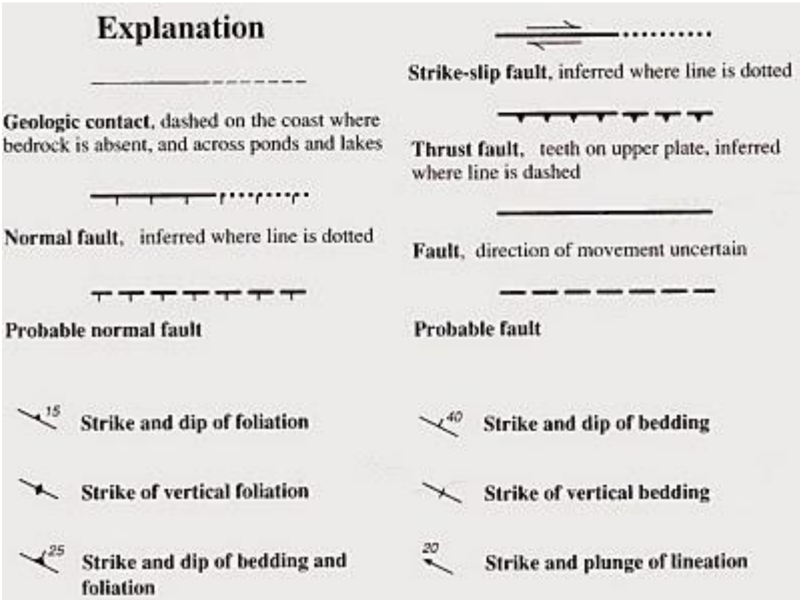
maps. Not every symbol is used on every map because different geologic areas contain different formations.

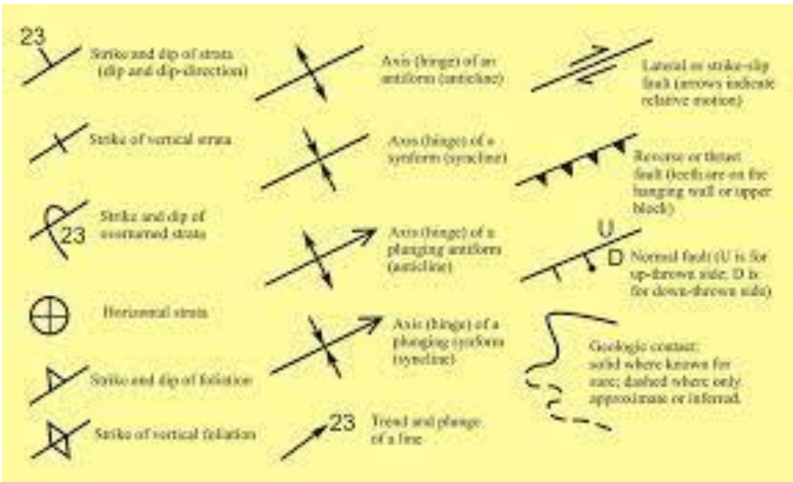
Examples of Geologic maps



Simplified geological map of the Eastern Desert of Egypt and Sinai showing the gold occurrences, the distribution of the main geological units and the broad structural trends. The map shows the wide distribution of the gold ores throughout the region. The geological map is modified after Johnson et al. (2011); gold occurrences are after Johnson et al. (2011, 2017) and Botros (2004).

Symbols on Geologic maps





Structural Geology Mapping

Structural mapping is the identification and characterization of structural expression. Structures include faults, folds, synclines and anticlines and lineaments. Understanding structures is the key to interpreting crustal movements that have shaped the present terrain. Structures can indicate potential locations of oil and gas reserves by characterizing both the underlying subsurface geometry of rock units and the amount of crustal deformation and stress experienced in a certain locale. Detailed examination of structure can be obtained by geophysical techniques such as seismic surveying.

Structures are also examined for clues to crustal movement and potential hazards, such as earthquakes, landslides, and volcanic activity. Identification of fault lines can facilitate land use planning by limiting construction over potentially dangerous zones of seismic activity.

▪ How do you do geological mapping?

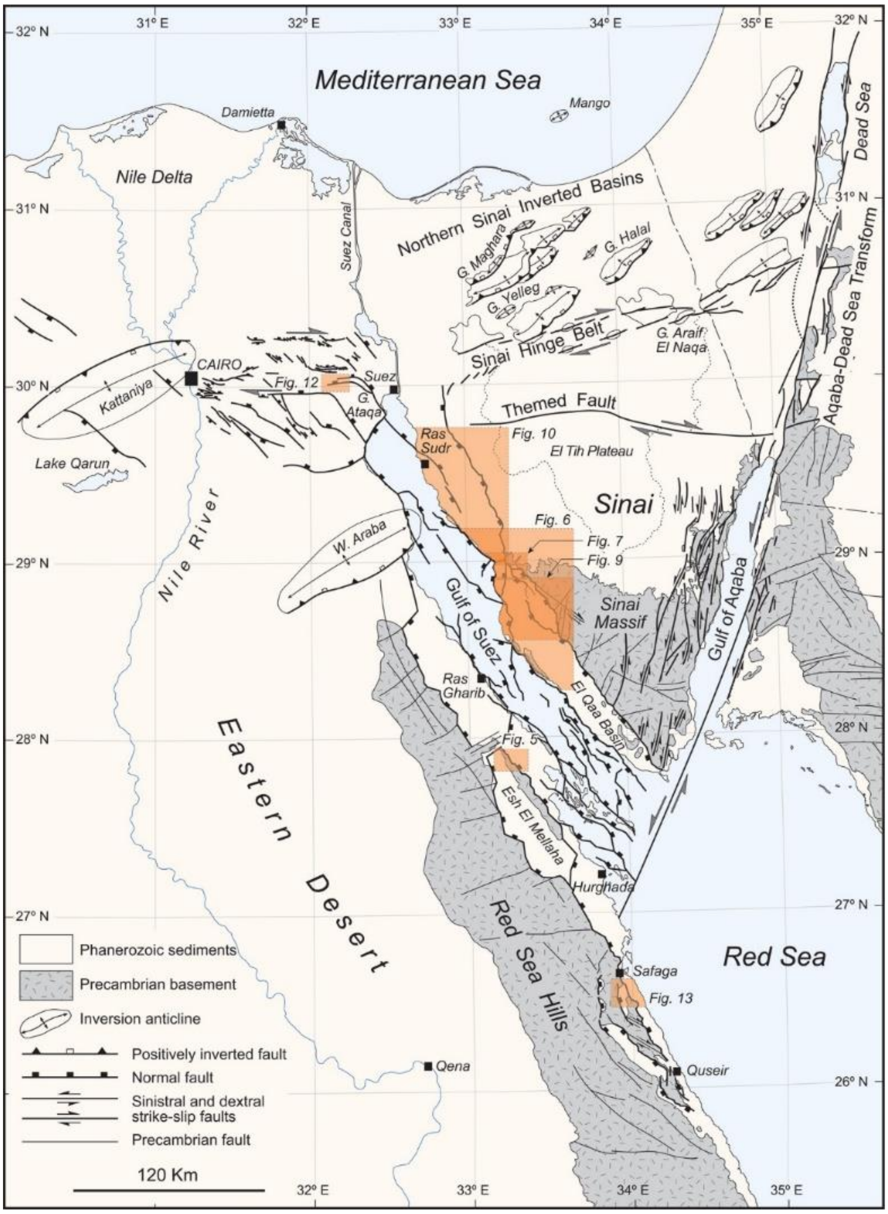
The steps of geological mapping activity are:

1. Make outcrop observation, and make a description of it.
2. Measure the position of rocks (strike and dip), geological structure elements, and other geological elements.
3. Make a record observations in a field notebook.
4. Determine the outcrop location by using GPS.

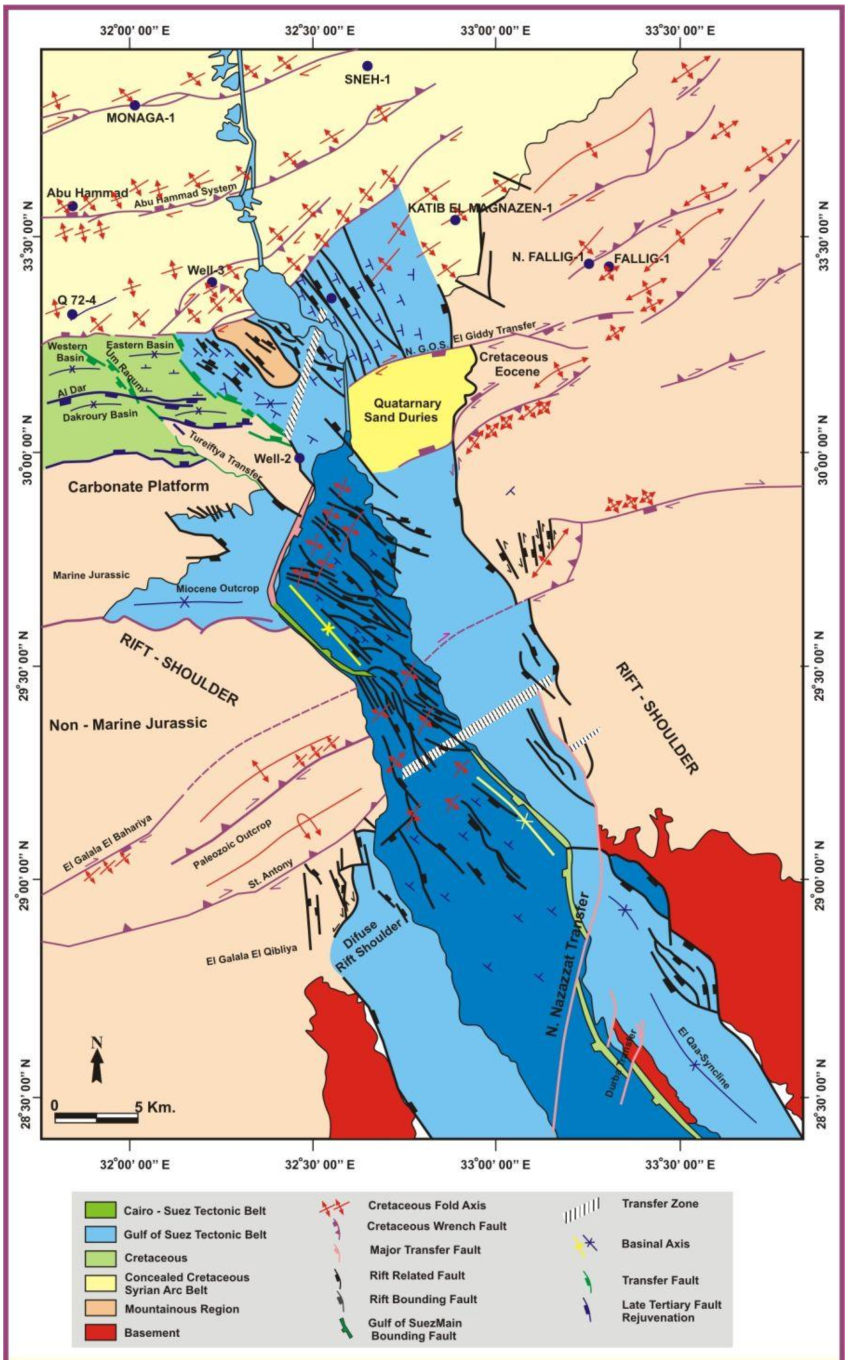
▪ What are the elements of structural geology?

Structural geologists measure a variety of planar features (bedding planes, foliation planes, fold axial planes, fault planes, and joints), and linear features (stretching lineation, in which minerals are ductilely extended; fold axes; and intersection lineations, the trace of a planar feature on another planar.

Examples of Structural Geology Maps

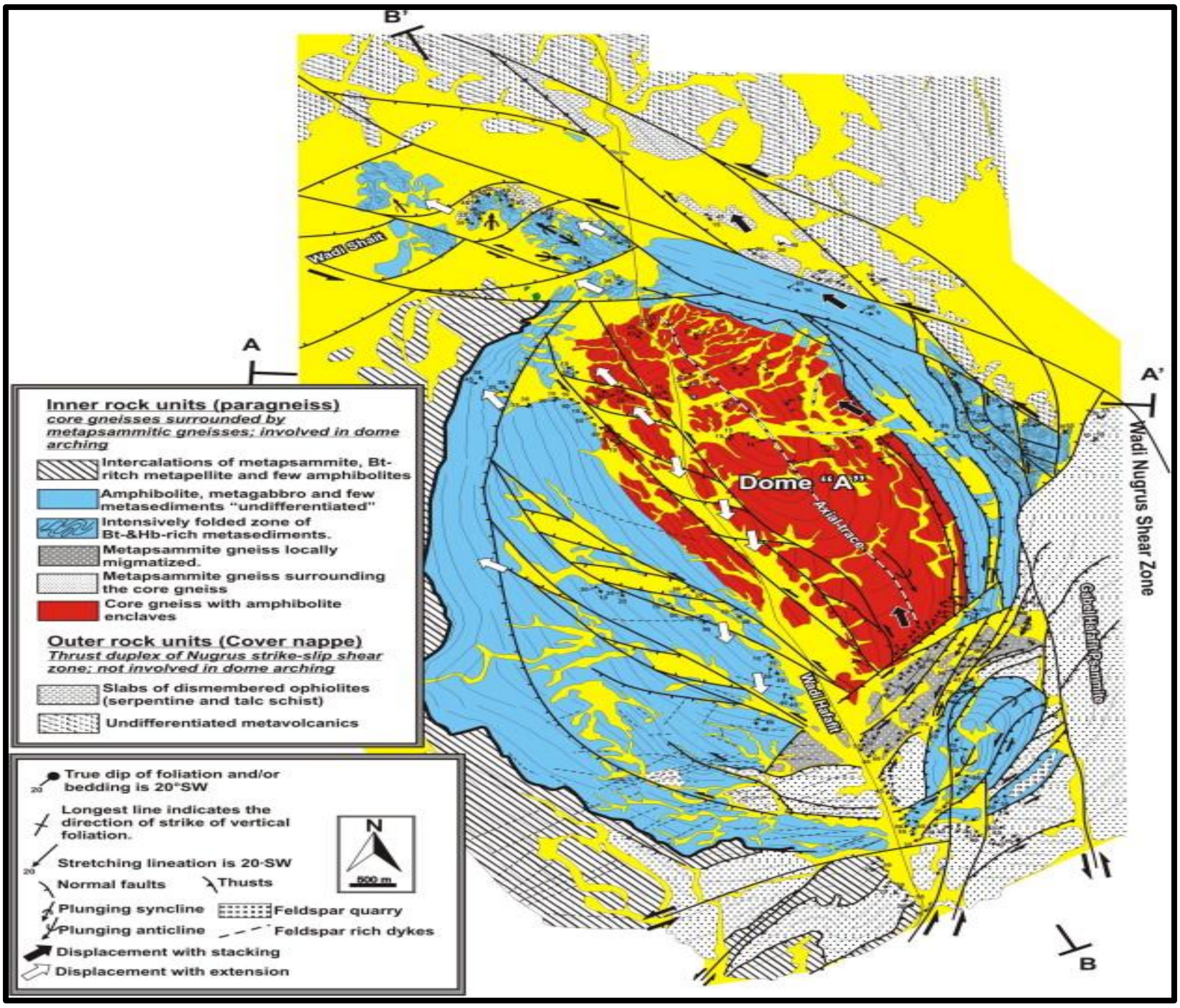


- Write a complete report about the structural elements controlling the map!

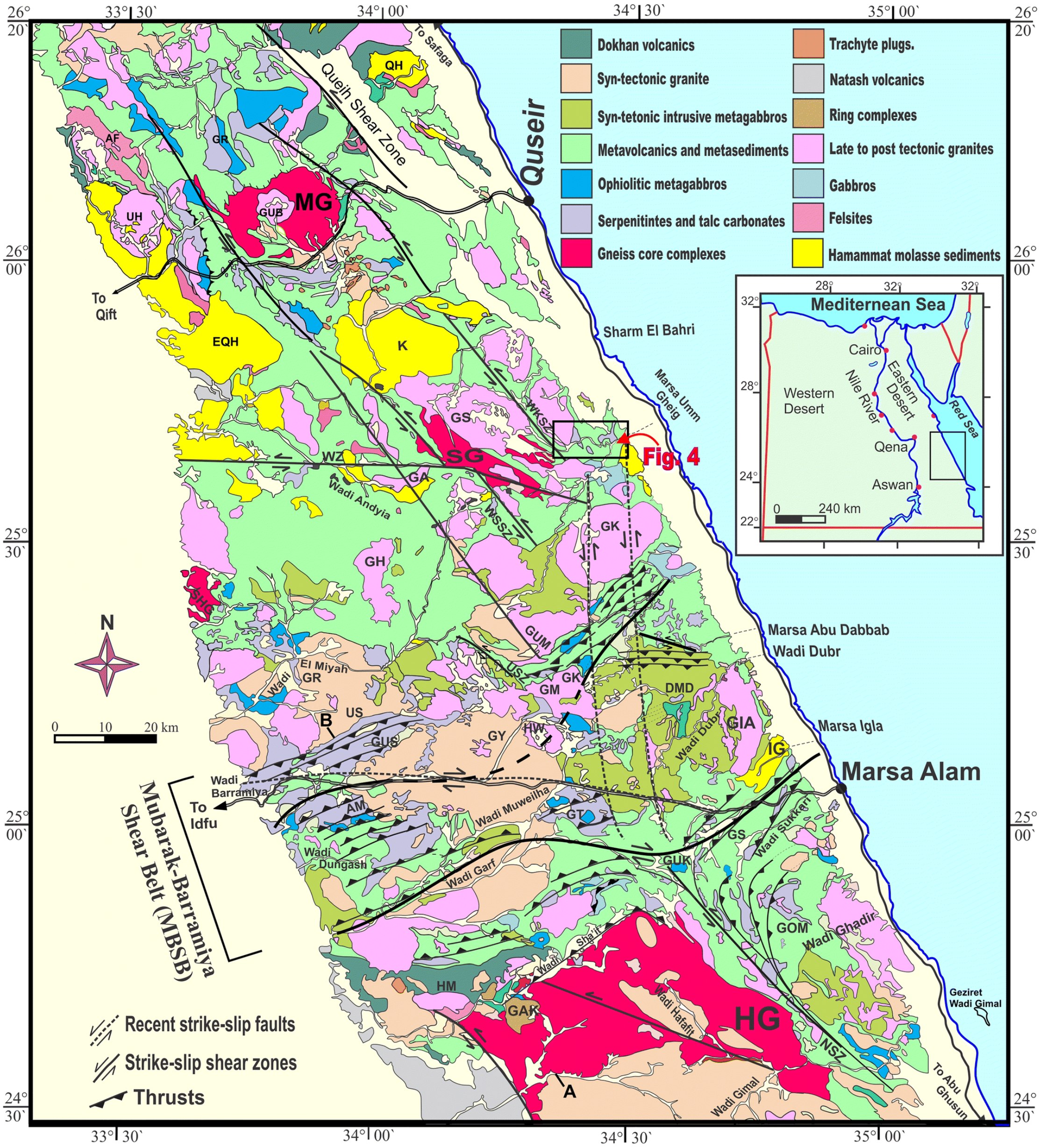


Regional Structural Setting North Gulf of Suez

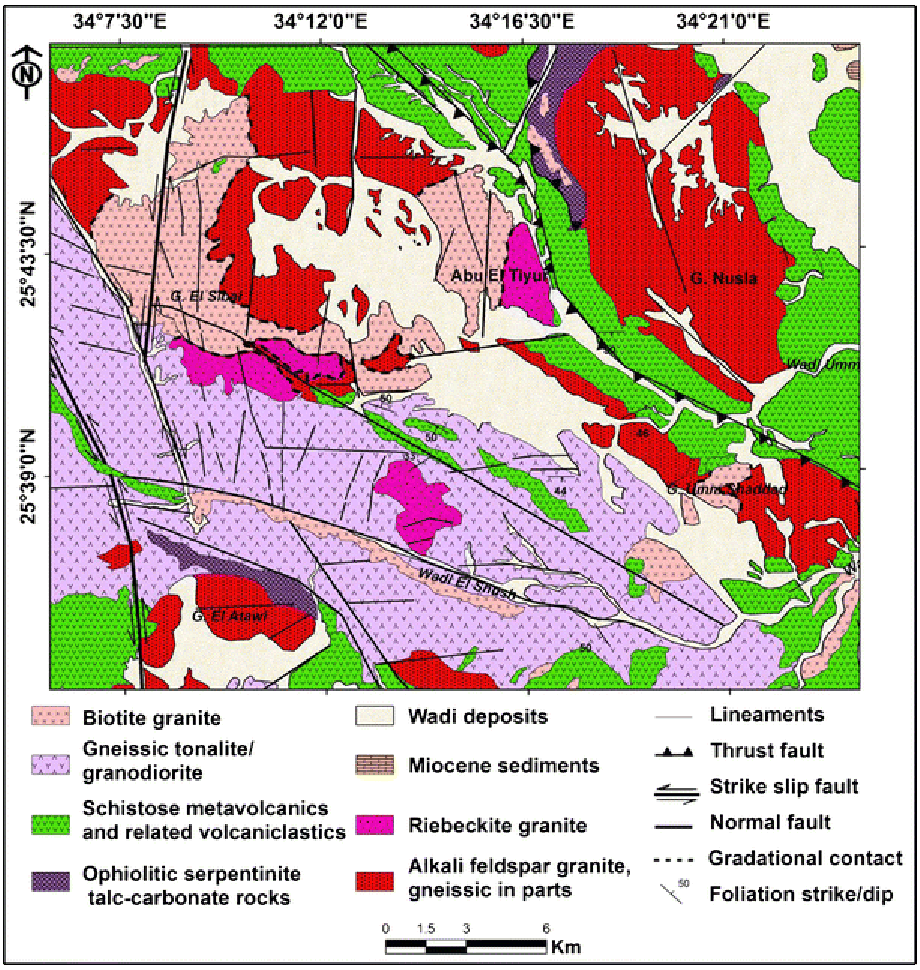
- Write a complete report about the structural elements controlling the map!



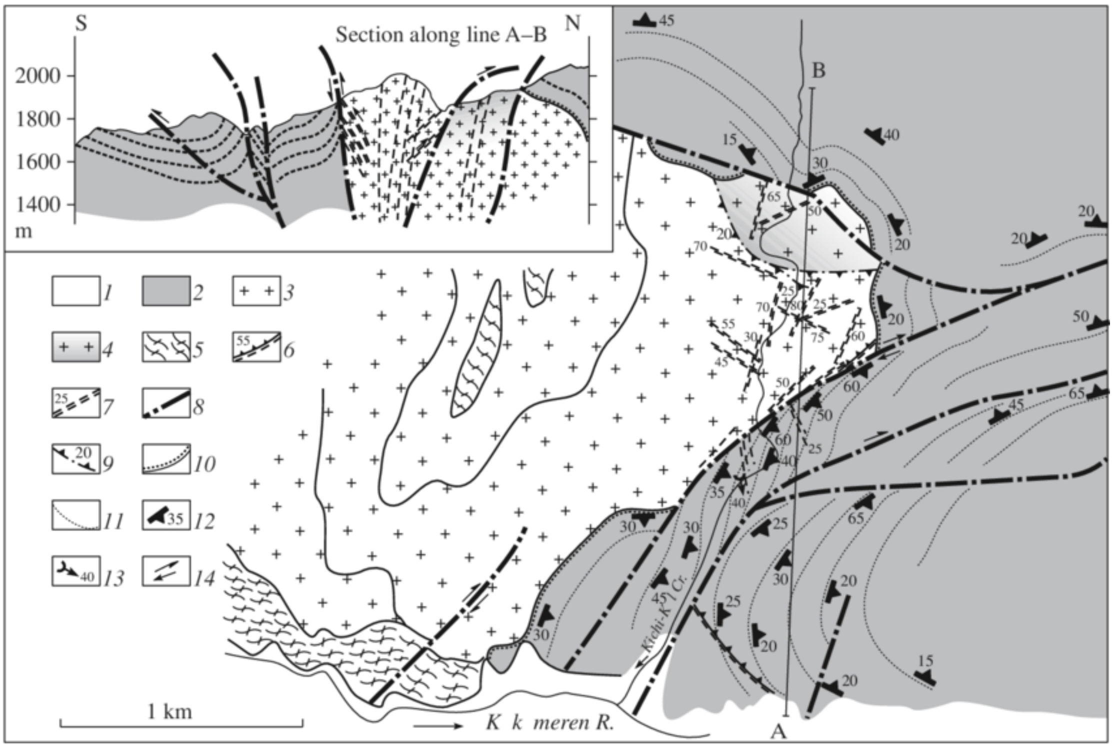
- Write a complete report about the structural elements controlling the map!



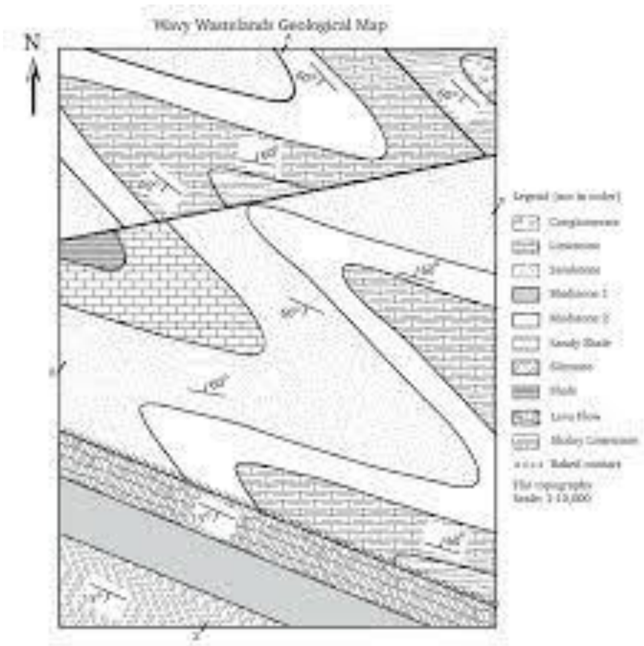
- Write a complete report about the structural elements controlling the map!



- Write a complete report about the structural elements controlling the map!



- Write a complete report about the structural elements controlling the map!



- Write a complete report about the structural elements controlling the map!

- Describe the structural elements in the above image.

- Most geologists prefer one of the following terms; to describe the displacement.
  (a) Joints.

  (b) Fractures.

  (c) Cracks.

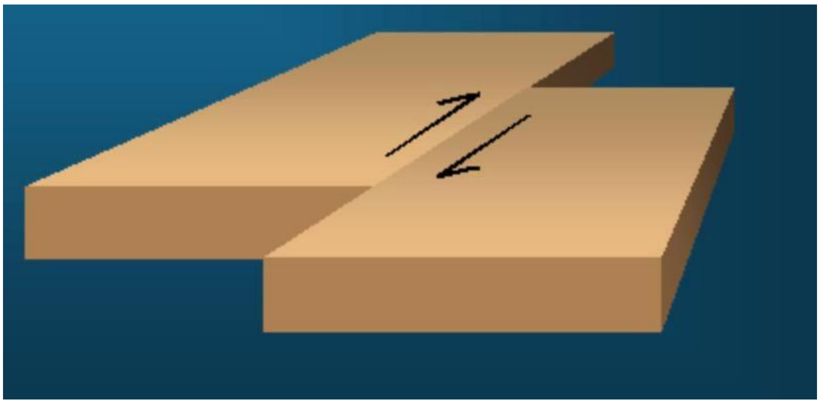
  (d) Faults.

What term best describes a surface across which there has been perceptible displacement?

- Which types of faults in the above image.

- Stresses produce strains in Earth materials. What are strains?
  - Distortions or changes in shapes

- In the following block diagram, what kind of fault is illustrated?



  - Left – lateral Strike- slip Fault

- Imagine the following. A set of rail road tracks are cut by a horizontal displacement. As you see in figure; what would you call the fault?

  - Right – lateral Strike- slip Fault

References

https://study.com/learn/lesson/reading-geological-map-colors-key-symbols.html

Anderson, r. n., et al. (1977), The mechanisms of heat transfer through the floor of the Indian ocean, *J. Geophys. Res.*, *82*, 3391–3409.

Andreas fault zone, J. (1992), *Geophys. Res.*, *85*, 6185–6222.

Brodsky, E. E., and H. kanamori (2001), Elastohydrodynamic lubricationof faults, *Journal of Geophysical Research-Solid Earth*, *106*, 16374–16305.

Chester, F. M., et al. (2004), Structure of large-displacement Strike-Slip Fault zones in the Brittle Continental Crust, in *Rheology and Deformation of the Lithosphere at Continental Margins*, edited by g. karner, et al., pp. 223–260, Columbia university Press, new york.

Chester, F. M., et al. (1993), Internal Structure and Weakening Mechanisms of the San-Andreas Fault, *J. Geophys. Res.-Solid Earth*, *98*, 771–786.

Davis, John C., (1986), Statistics and data analysis in geology: 2nd ed., John Wiley & Sons, New

York , 646p.

di Toro, g., and g. Pennacchioni (2005), Fault plane processes and mesoscopic structure of a strong-type seismogenic fault in tonalites (Adamello batholith, Southern Alps), *Tectonophysics*, *402*, 55–80.

Faulkner, d. r., et al. (2003), on the internal structure and mechanics of large strike-slip fault zones: field observations of the Carboneras faultin southeastern Spain, *Tectonophysics*, *367*, 235–251.

Hardebeck, J. l., and E. Hauksson (1999), role of f luids in faulting

inferred from stress field signatures, *Science*, *285*, 236–239.

Rice, J. r. (1992), Fault stress states, pore pressure distributions, and the weakness of the San Andreas fault, in *Fault Mechanics and Transport Properties of Rocks*, edited by B. Evans and T.-F. Wong, pp. 475–504, Academic Press, London

Pearce, J.A., (2003). Supra-subduction zone ophiolites: the search for modern analogues. In: Dilek, Y., Newcomb, S. (Eds.), Ophiolite Concept and the Evolution of Geological Thought. Geological Society of America Special Paper 373, pp.295-269.

Marshak, Stephen and Mitra, Gautam, (1988), Basic methods of structural geology: Prentice Hall, Englewood Cliffs, New Jersey, 446p.

Ramsay, John G., 1967, Folding and Fracturing of Rocks: New York, McGraw-Hill, 568p.

Stern, R.J., (2005), Evidence from ophiolites, blueschists, and ultrahigh-pressure metamorphic terranes that modern episodes of subduction tectonics began in Neoproterozoic time. Geology 33, 557–560.

Stern, R.J., (2008), Neoproterozoic crustal growth: the solid Earth system during a critical episode of Earth history. Gondwana Research 14, 33–50.

http://www.utahpictures.com/Checkerboard.html.

http://volcanoes.usgs.gov/Products/Pglossary/PillowLava.html

http://volcanoes.usgs.gov/Products/Pglossary/ancientseq.html

http://www.geology.washington.edu/~cowan/faultrocks.html#photo

Scholz, C. H., The Mechanics of Earthquakes and Faulting, 2nd. ed., Cambridge University Press, 471 p., 2002

Coney, P. J., Cordilleran metamorphic core complexes; an overview, *in:*Crittenden, M.,D., Jr., Coney, P. J., and G. H. Davis (eds), Cordilleran metamorphic core complexes, Geological Society of America Memoir 153, 7-31. 1980.

http://home.earthlink.net/~rhaughy/ROCKS.HTM

http://earth.leeds.ac.uk/assynt/quartzmfr.htm

http://www.lpl.arizona.edu/~rlorenz/pseud.html

http://www.geolab.unc.edu/Petunia/IgMetAtlas/meta-micro/mylonite.X.html

http://www.nps.gov/deva/pphtml/maps.html

http://www.geophysics.rice.edu/department/research/julia1/julia1.html

http://earth.leeds.ac.uk/mtb/background/nwmap.htm

http://earth.leeds.ac.uk/assynt/quartzmfr.htm