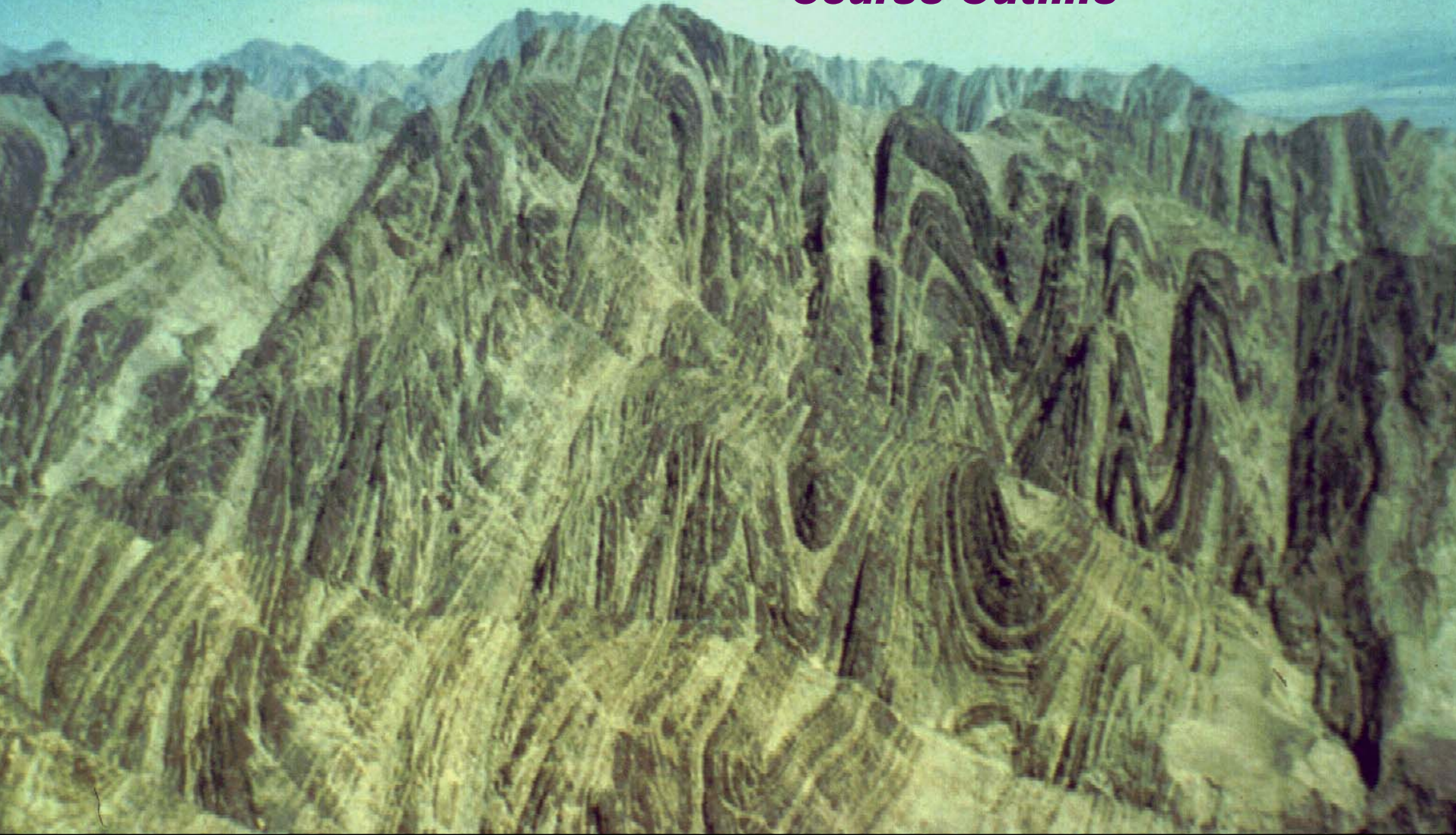


ERTH2004

**Deformation and Structural Geology:
*Course Outline***



Rod Holcombe
Rm 236 Steele Bldg

Deformation and Structural Geology:

Analysis of ductile and brittle deformation structures. Stress theory. Dynamics of folding and faulting. Fracture analysis. Geological map, mine, and subsurface interpretation

Course Coordinator: Assoc.Prof. Rod Holcombe.

Steele 236 email: rodh@earth.uq.edu.au

Consultation hours: Mon 2-4; Tues 11-1; Wed 2-4

Lab Tutor: Megan Packer (Steele 254)

Course Home page:

<http://www.earth.uq.edu.au/~rodh/courses/erth2004/>

Contains links to:

- powerpoint lecture notes
- theory and practical manuals,
- other materials and weblinks

The official course profile (nazi-version) can be found through:

<http://www.earth.uq.edu.au/>

Course Outline (cont)

Assumed Background

This course follows directly on the lectures in structural geology and the mapping practicals in EARTH1001. Students should be totally familiar with terms and concepts introduced at that level. **Pertinent terms and concepts that should form prior knowledge for the course are summarised at the end of this outline.** Re-read the explanatory notes that accompany the 1st Level mapping practicals before the first EARTH2004 practical session. Any of this assumed geological background is also examinable in this course. The course also assumes competency in basic Mathematics, particularly trigonometry.

Teaching Mode

EARTH2004 consists of 24 lectures and 13 three-hour practicals, **including a field trip held during one of the practical classes.** In addition, you will be assigned two projects during the semester to be completed in your own time. One of these will be a laboratory-based exercise to be completed individually, and the other will be a field-based team exercise.

The lectures are intended to be a guide and a supplement to your reading and understanding of the assigned text material and provided class notes. Emphasis in examination will be on your understanding of the course, not on your ability to simply memorise lecture notes. Several lectures, toward the end of the semester, will include material based on personal professional experience and case histories. This material is not available from any other source, so attendance at lectures is strongly advised.

Practical classes will concentrate on developing tools to interpret geological maps, and to draw viable, accurate cross-sections. Lab classes will be under the supervision of the lecturer and a demonstrator. Practical material that is not completed within the timetabled period must be completed in your own time.

The completed practical exercises (maps, etc.) of the previous practical class must be available for inspection, or handing in for evaluation, at the beginning of each practical session. *Satisfactory* attendance and completion of all lab exercises is a **requirement for passing** the course (see Assessment). Exercises from the initial 3 practical classes will be assigned a simple OK/not-OK grade. The exercises from each subsequent week will be assigned a mark out of 5, with 5 reserved for excellent work; 3 for just-OK; 1 for entirely unsatisfactory; and zero for non-attendance. A zero can be subsequently upgraded if a satisfactory explanation is tendered and the work completed satisfactorily by the following class.

Course Outline (cont)

★ Assessment:

(Note: this assessment schedule may change after consultation and class approval)

<u>Theory</u>	(2 hour central exam) -	50%
<u>Practical:</u>		
	Satisfactory attendance and completion of lab exercises *	10%
	Lab Project	15%
	Field Project (Initial 8%; Final 17%)	25%

(*Must obtain at least 50% of the Attendance/satisfactory completion mark to pass the course)

Assignment due dates:

Field Project	Initial: Monday, April 14 th ; Final: Monday, June 2 nd .
Lab Project:	Friday May 2 nd

Course Outline (cont)

★ Assessment criteria

Theory examination

The theory examination will be assessed in terms of the extent to which the student demonstrates an ability to:

- Define the array of geological structures covered in the course and to recognise the field characteristics of each;
- Define, explain and interrelate the key concepts involved in the course;
- Recognise the appropriate theory required to solve an observed problem;
- Relate basic theory to the structures observed in real rocks.

Laboratory and project reports

Laboratory and project reports will be assessed in terms of the extent to which the student demonstrates an ability to:

- Draw on a theoretical understanding of the array of geological structures to interpret them in rocks and maps;
- Recognise the appropriate theory required to solve an observed problem;
- Present results of that analysis in a **professional manner**.

Precision and accuracy are extremely important professional attributes in structural geology. Imprecise cross-sections or maps can cause major cost overruns.

Thus "satisfactory" as an assessment criteria means that work must be as neat and precise as possible.

Most classes will consist of cross-section construction exercises for which you will **require basic drawing instruments (good ruler, compass, protractor), sharp pencils, drawing paper, and a supply of transparent tracing paper (thin bond will do).**

Constructions done with unsharpened pencils, or with thick ink pens, or without using precision aids such as ruler, protractor, or compass will be marked as unsatisfactory.

Course Outline (cont)

★ Plagiarism

- See the course profile for the complete policy on plagiarism and for definitions of what constitutes plagiarism.
- In this course, student's assessed work must be entirely their own. This includes laboratory assignments and project reports, except where indicated for the field-based project.
- Informal group work is permitted within the practical classes exercises. That is, students may query and assist one another but the final work presented must be formulated and written by themselves.
- The laboratory-based project is to be carried out entirely independently. Student who require help with the project should consult with the course coordinator or the tutor, rather than one another.
- The field-based project is in two parts: in the group part, the group are expected to work together to produce a group effort. In those parts indicated as 'individual', the work presented must be the student's own analysis of the problem.
- Students are encouraged to study together and to discuss ideas, but this should not result in students handing in the same or similar assessment work. Do not allow another student to copy your work. While students may discuss approaches to tackling a practical or assignment problem, care must be taken to submit individual and different answers to the problem. Submitting the same or largely similar answers to an assignment or tutorial problem may constitute misconduct.
- **If an act of plagiarism is proven, the results of the assessment may be annulled and other action may be taken as is considered appropriate in the circumstances of the case.**

Course Outline (cont)

★ Text and references

Primary Text: Structural Geology of Rocks and Regions

George Davis & Stephen Reynolds; 2nd ed. 1996; John Wiley and Sons

Other References

Principles of Structural Geology, John Suppe; 1985; Prentice Hall.

This was a previous text and is still an excellent reference.

Structural Geology, Robert J. Twiss, Eldridge M. Moores. 1992. New York : W.H. Freeman.

Foundations of Structural Geology; Park; 2nd ed. 1989; Blackie.

This text contains a very concise (and accurate) summary of the structural geology topics covered in this course.

The Techniques of Modern Structural Geology: (Vols. 1&2: Folds and Fractures); Ramsay and Huber; 1987;

Academic Press. There is also a volume 3 – but it is not a particularly good reference.

Both volumes in this series are extremely good.

Geol Soc London Handbook series: The mapping of geological structures: Ken McClay

This is an excellent summary both of basic structural concepts and of field techniques.

Basic Methods of Structural Geology, Stephen Marshak & Gautam Mitra; 1988; Prentice Hall

Previously the text for the laboratory work. Excellent reference book, but many exercises are rife with errors.

Structural Analysis and Synthesis (2nd Edition), Stephen Rowland & Ernest Duebendorfer; 1994; Blackwell Scientific

Excellent reference for the practical classes in the first half of the semester. Major problem is its universal use of American quadrant notation for directions (although you **are** required to become familiar with quadrant notation).

Structural Geology: an introduction to geometrical techniques (3rd ed.), Ragan

Reasonable basic reference for standard geometrical techniques.

Applied Subsurface Geological Mapping, Tearpock and Bishke

This is a text of petroleum-style structural geology. Takes many of the relatively simple mapping techniques developed in first and second level to advanced levels not covered in this or the third level course. Material from the sections on fault-related folding and balanced sections are used in the class lectures.

Course goals

★ Aim:

– To introduce you to:

- the array of structures that deform the Earth's crust
- to the basic tools required to map such structures
- to the tools required to solve their 3-D geometry
- to the theoretical mechanisms by which such structures form so that when you meet an unknown structure you have the understanding to be able to interpret it correctly

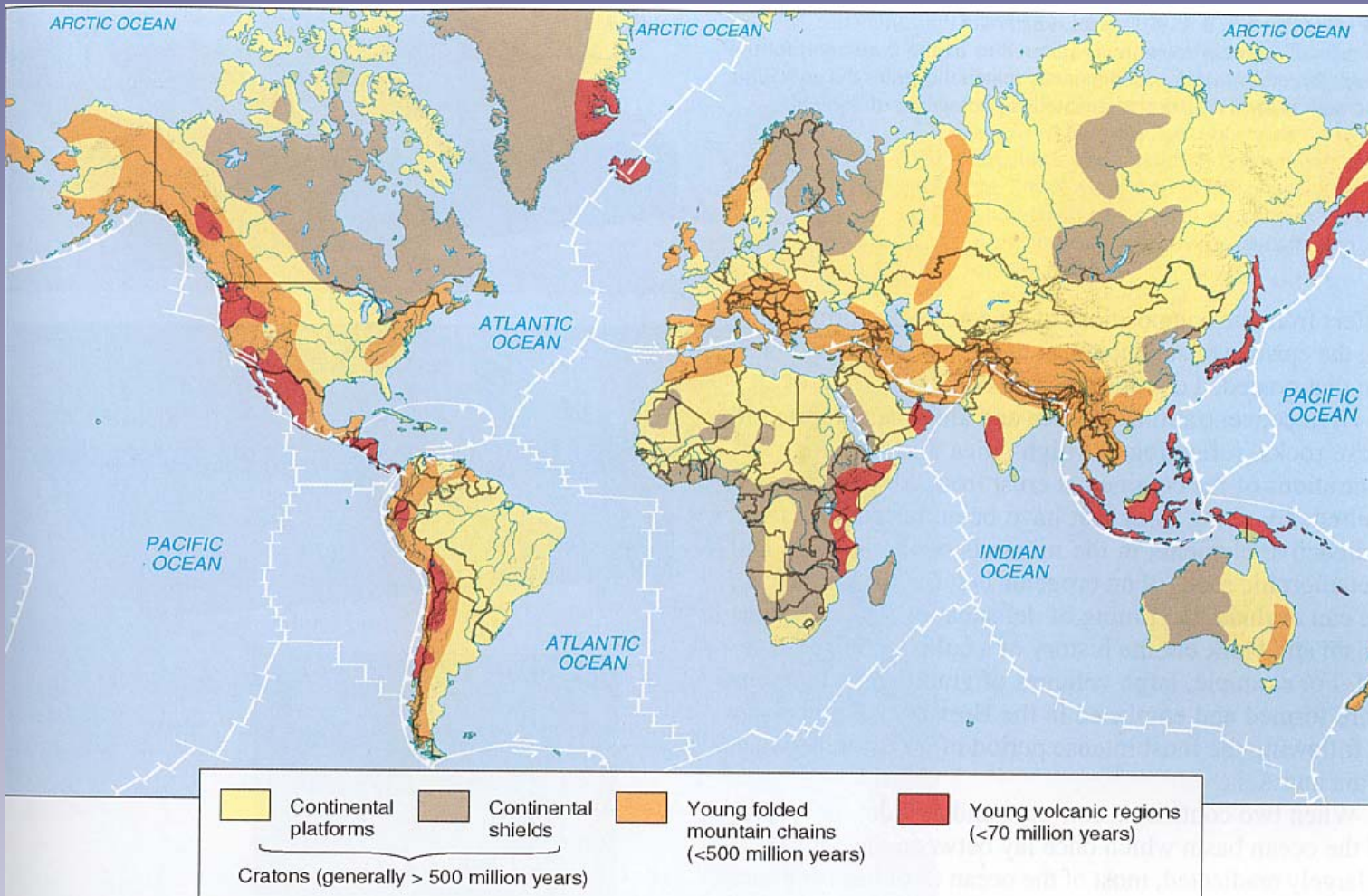
- ★ Course is based on teaching you to be able to deal with areas that have been deformed once, such as in simple fold and thrust belts
- ★ Emphasis is on understanding the underlying theory of how simple structures form, and on how they are mapped and analysed by **professional geologists**

Orogenic belts

Scars of ancient mountain ranges

* Phanerozoic orogenic belts of the world

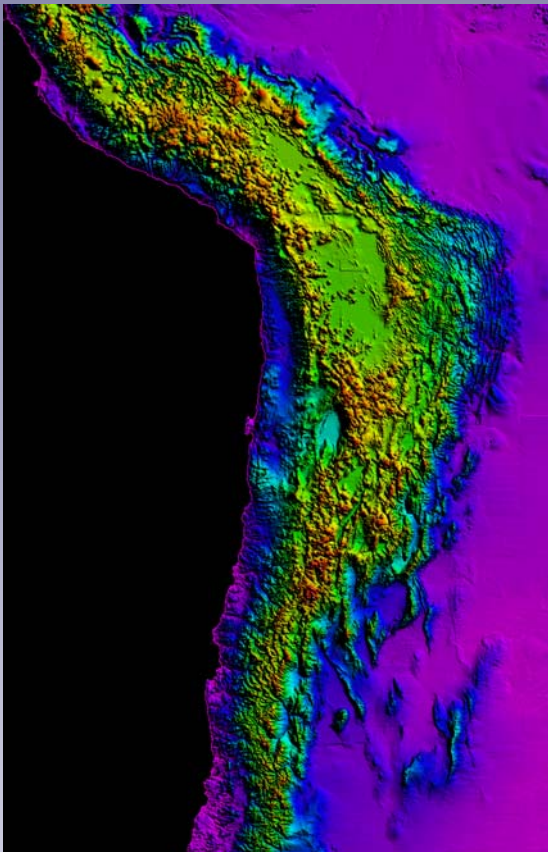
– Note:
also known as
mobile
belts,
fold belts,
etc



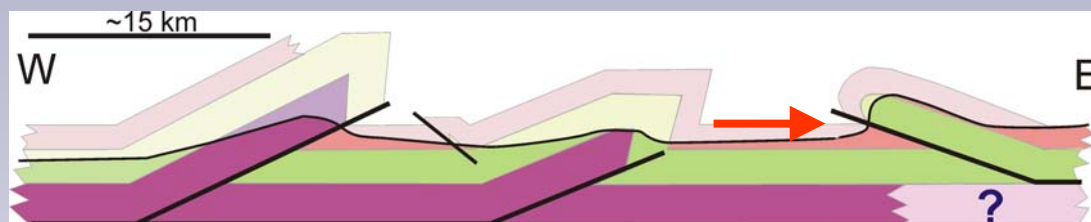
Young Mountain ranges

★ Andes :

- Fold-thrust mountain belt
- 6000+ metres relief
- Formed in last 45 my



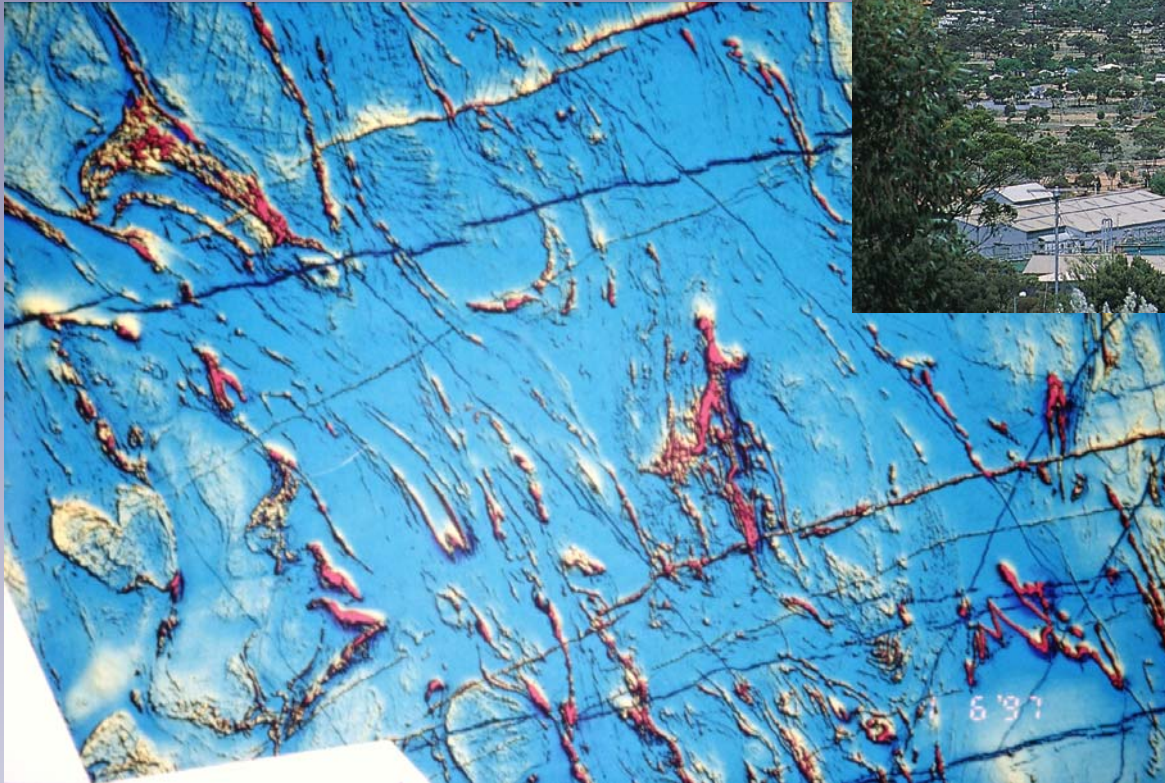
Fold-thrust structures in Andes



Ancient mountain ranges

* Yilgarn, W.A.

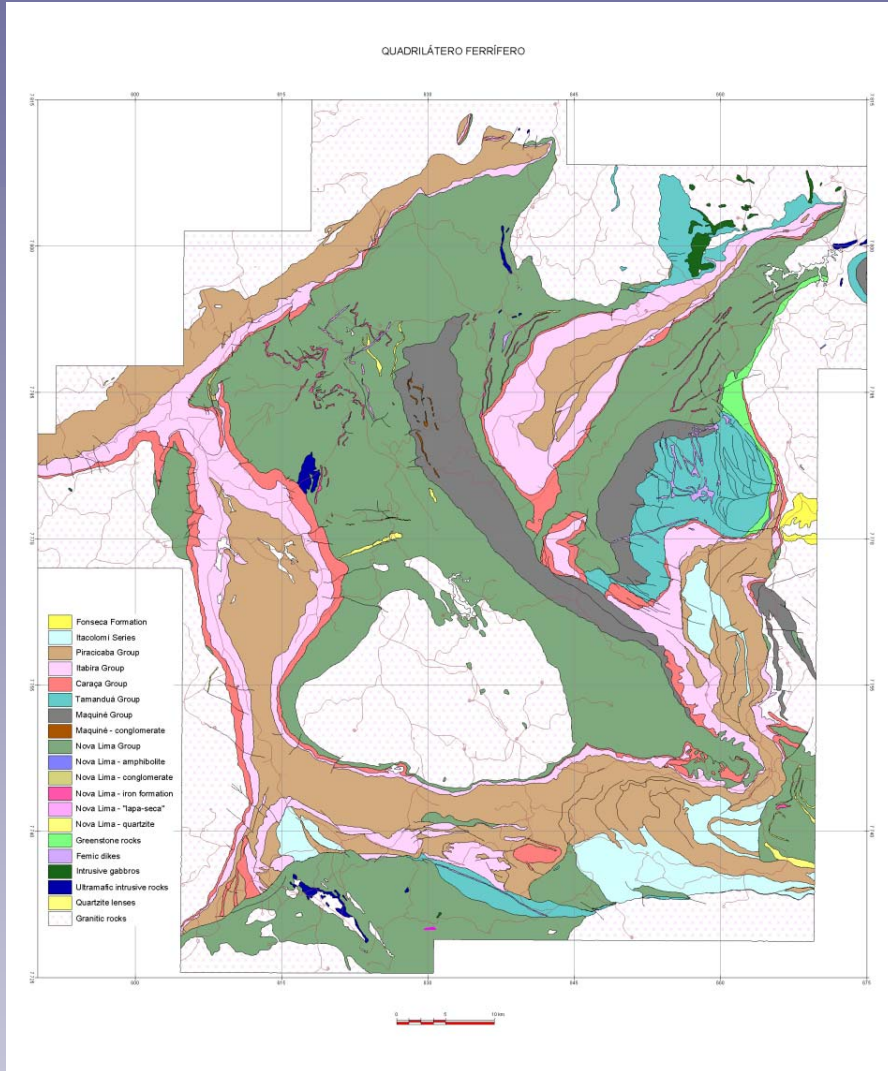
- Ancient mountain belt formed 2650 million years ago
- Formed over ~50 million year period
- Reached heights of ~3000m



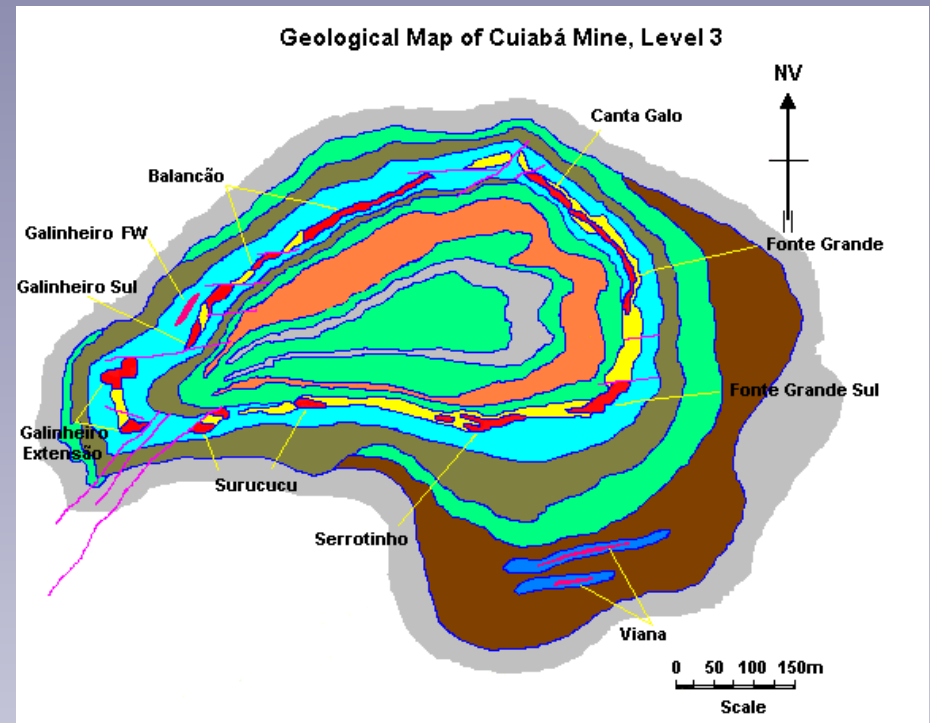
View north from Kalgoorlie

Magnetic image of Yilgarn area (Kalgoorlie), W.A. showing strongly folded and faulted strata

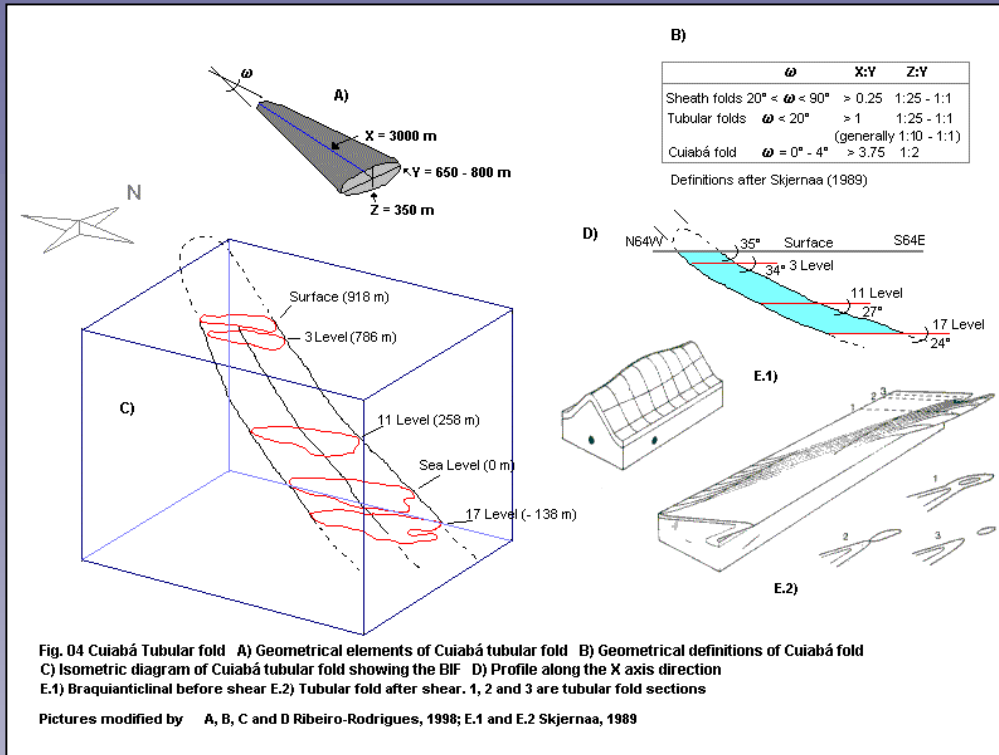
“Quadrilateral Ferrifero” (Iron Quadrangle) Brazil



✳ Cuiaba Mine
 — ~9,000,000 ozs of gold



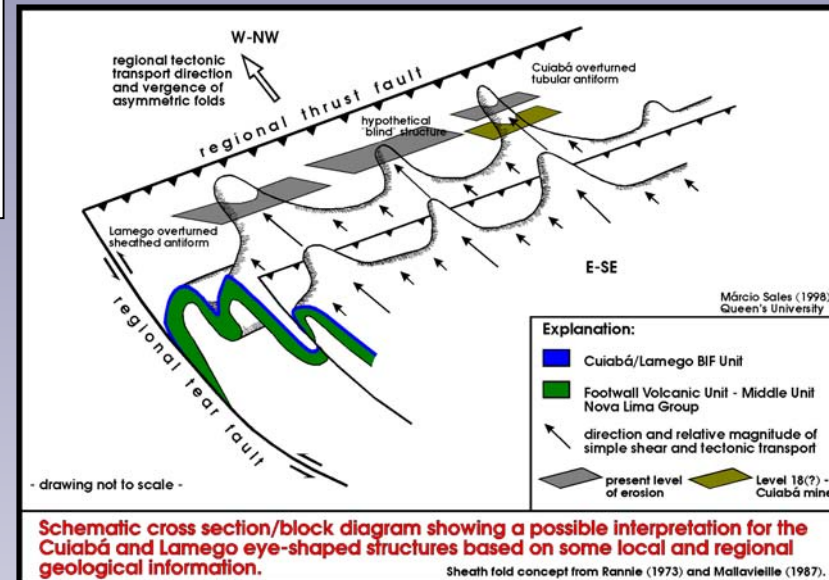
Cuiaba Mine structure



- Apparent tubular fold
- 500 metres across
- 3+km long
- Plunging (inclined) $\sim 30^\circ$

Sheath fold hypothesis:

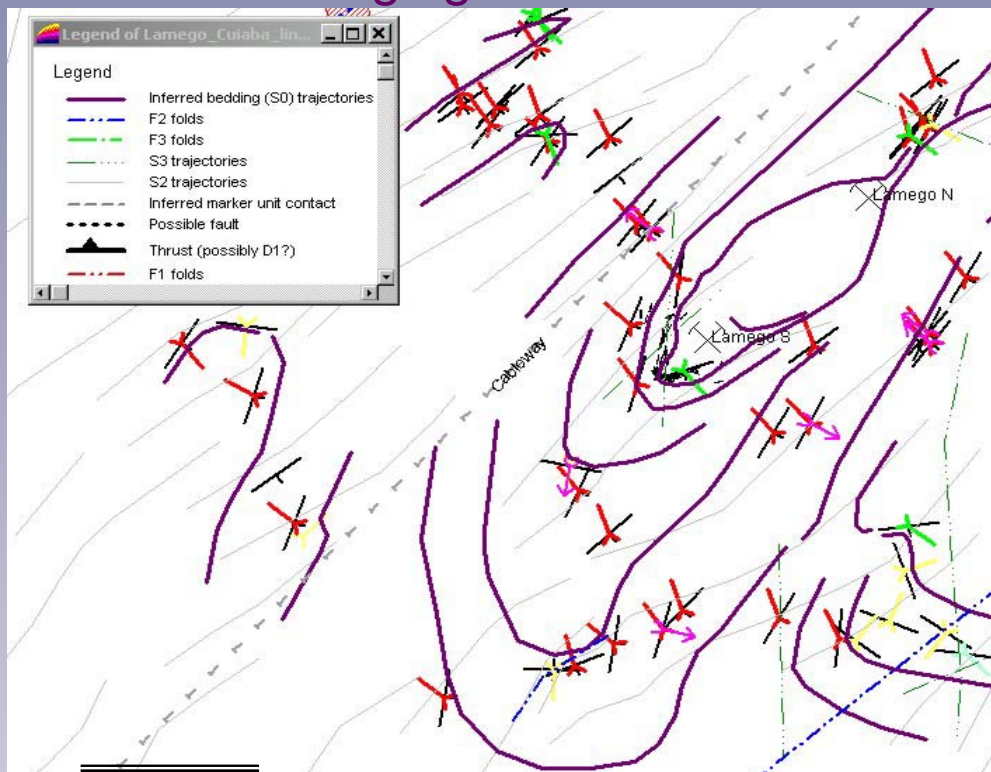
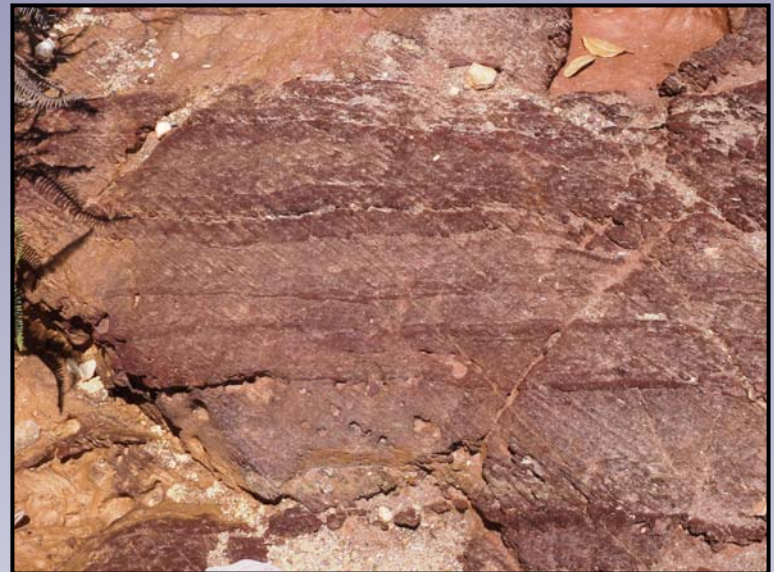
- Abnormal stretching during intense shear deformation



Solving structure in areas of monotonous rock type

✳ Tools:

- Vergence
- Trend surface maps
- Younging



~1km

Assumed knowledge

* Terms and concepts from EARTH1001

– Theory:

stress terms: tension, compression, shear stress

strain terms: extension, contraction, shear strain

rheology terms: elastic deformation, plastic deformation, fracture, flow brittle behaviour, ductile behaviour; competent rocks, incompetent rocks

tectonics: uplift, orogeny, mountain building, crustal thickening, craton, orogen (mobile belt, fold belt)

crustal extension, crustal thinning, plates, slab, subduction, collision

folds: antiformal, synform, anticline, syncline, monocline

limb, hinge, axis, axial plane; upright, plunging, overturned, recumbent fault bend fold, drape fold

gentle, closed, tight, isoclinal; parallel/similar, symmetric/asymmetric, concentric/rounded/angular/chevron, kink band

foliation, rock cleavage, lineation

buckling, bending, passive flattening/amplification, shear folding

faults: fault block, hangingwall, footwall

strike-slip fault, dip-slip fault, normal fault, reverse fault, domino fault, listric fault

horst, graben, ramp, décollement, detachment fault

thrust, nappe, imbrication, separation, slip, throw, heave

fault breccia, fault gouge, slickensides, slickenlines

fault scarp

joints and veins: systematic and non-systematic joints, joint patterns in different rock types, cooling/columnar joints, sheeting joints, unloading; modes of failure

veins, en echelon (gash) veins

fractures as aquifers, landscape controls, karst topography;

geotechnical/engineering aspects of fractures,

Assumed knowledge

✳ Terms and concepts from EARTH1001

– Practical:

- **Be able to** interpret basic topographic and geological maps, and to construct topographic profiles and geological cross-sections from them.
- **Understand what is meant by:** beds, strata, layers, Members, Formations, Groups, contacts, disconformities, unconformities, structure contours and be able to recognize them on maps. Be able to recognise igneous flows, plugs, dykes, sills (laccoliths), and plutons.
- **Understand the terms:** dip, strike, dip direction, plunge, plunge direction, azimuth, apparent dip, easting, northing, latitude, longitude, true north, magnetic north, grid north.
- **Basic techniques:**
 - Understand and interpret the map patterns of homoclinal planes across topography
 - Be able to determine strike and dip of such planes from the map pattern.
 - Understand and be able to construct structure contours from such data
 - Be able to reconstruct the map pattern of such planes given the strike and dip
 - Be able to construct map contours from any point data values
 - Be able to incorporate simply horizontal folds and simple faults in cross-sections
 - Understand the map pattern of plunging folds on horizontal surfaces.

Useful weblinks

★ Rick Allmendinger's course at Cornell

- http://www.geo.cornell.edu/geology/classes/RWA/GS_326/GEOL326.html#aa50
 - Lecture notes, animations, software

★ Structural geology on the web

- http://www.science.smith.edu/departments/Geology/Structure_Resources/
 - Links to all sorts of resources

★ Prakash P Roday's site at Dr H S Gour University, India

- <http://www.structural-geology-portal.com/>
 - An amazing (and noisy) collection of animation and structural links

★ Learning Journals Geoscience Modules and Courses

- <http://www.learninggeoscience.net/modules.php>
 - A superb set of online manuals with animations

★ Drs Reish and Girty, San Diego State U

- [http://www.geology.sdsu.edu/visualstructure/Visualising structural geology \(manuals and animations\)](http://www.geology.sdsu.edu/visualstructure/Visualising_structural_geology_(manuals_and_animations))
 - excellent for visualising basic techniques, stereographic projections, etc

★ Monash Microstructure short course

- <http://www.earth.monash.edu.au/Teaching/mscourse/>
 - The best on-line site for deformation mechanisms and microstructure

Useful weblinks cont.

★ <http://www.scotese.com/>

- Continental reconstructions, map animations, etc

