DURCHBEWEGUNG TEXTURES, SUBTERRANEAN SEDIMENTATION AND THE LINK TO MINERALISATION IN THE CENTRAL AFRICAN COPPERBELT

Dedicated to Martin Jackson
May 31 2016

DURCHBEWEGUNG TEXTURES?

SUBTERRANEAN SEDIMENTATION ?

THE CENTRAL AFRICAN COPPERBELT

GENETIC MODEL

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WHAT ARE DURCHBEWEGUNG TEXTURES?

German "durch bewegung" = "by movement or motion"

Durchbewegung texture definition:

Competent sulphide or silicate clasts in a matrix of less competent sulphides

Clasts commonly rounded

WHAT ARE DURCHBEWEGUNG TEXTURES?

Process:

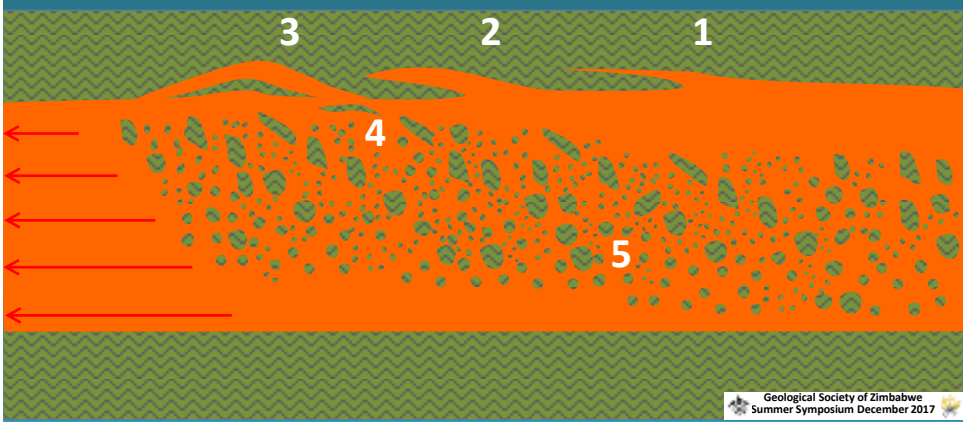
Movement of massive, high viscosity ductile sulphides during deformation involving separation, milling and rotational movement of more competent rocks/minerals incorporated into the sulphide

Matrix typically chalcopyrite or pyrrhotite

Clasts more competent sulphides (pyrite/millerite) or silicate rocks/minerals

WHAT ARE DURCHBEWEGUNG TEXTURES?

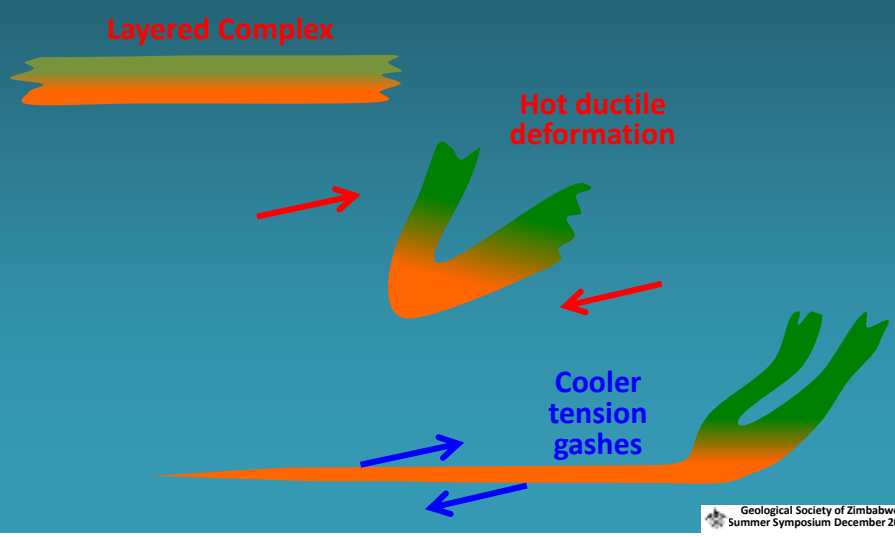
Sulphides act as fluids which rotate and abrade clasts



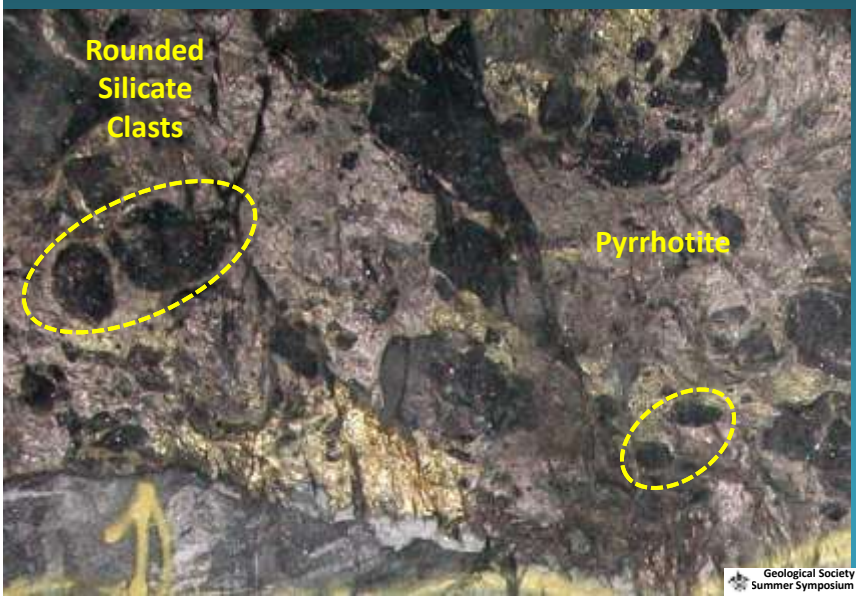
DURCHBEWEGUNG TEXTURES EXAMPLES

DURCHBEWEGUNG TEXTURES

Deformed massive sulphides Selebi Phikwe Model



DURCHBEWEGUNG TEXTURE



DURCHBEWEGUNG TEXTURE

WHAT ARE DURCHBEWEGUNG TEXTURES?

Broaden definition to include any ductile medium

That separates, transports, mills abrades and rotates more brittle clasts

So include the following transporting mediums:

Pseudotachylite
Kimberlite
Evaporites
Igneous rocks ??

The process – transporting medium rounds the clasts

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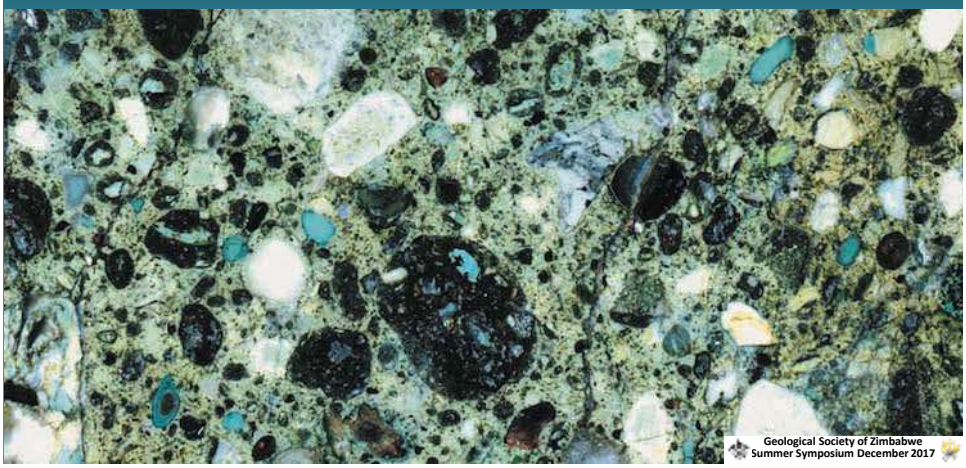
DURCHBEWEGUNG TEXTURES?

Examples: Kimberlite xenoliths and xenocrysts

Grinding medium: carbon dioxide, water and dust particles



WHAT ARE DURCHBEWEGUNG TEXTURES?

Examples: Pseudotachylite

Grinding medium: liquid silicates

DURCHBEWEGUNG TEXTURES?

Examples: Igneous rocks???

DURCHBEWEGUNG TEXTURES?

Examples: Evaporites

Formation of evaporites and features

Marine and Intracontinental depositional settings

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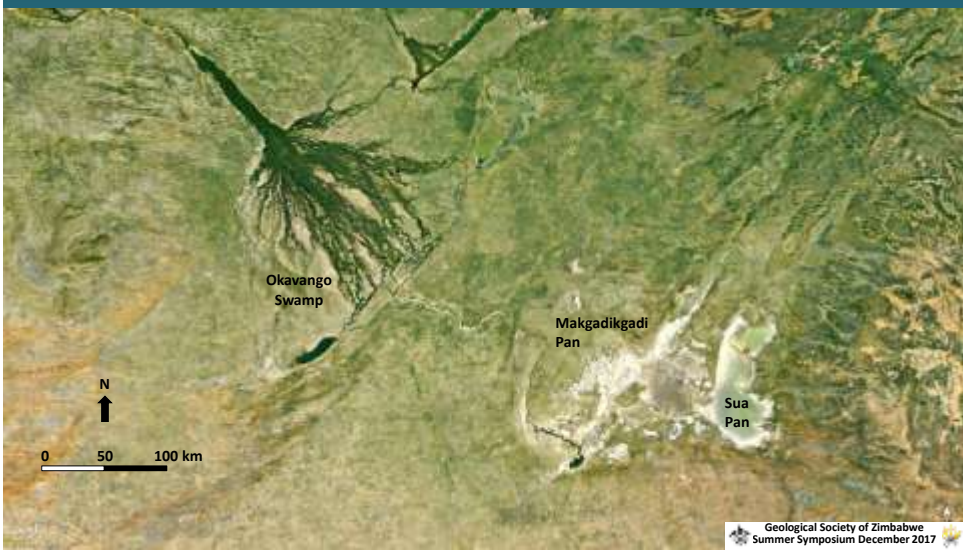
ORIGIN OF EVAPORITES

Intracontinental basins

Intracontinental basins – plenty of examples

Bonneville Salt Flats / Salton Sea / Sea of Galilee / Etosha & Makgadikgadi Pans



ORIGIN OF EVAPORITES

Intracontinental basins

Intracontinental basins

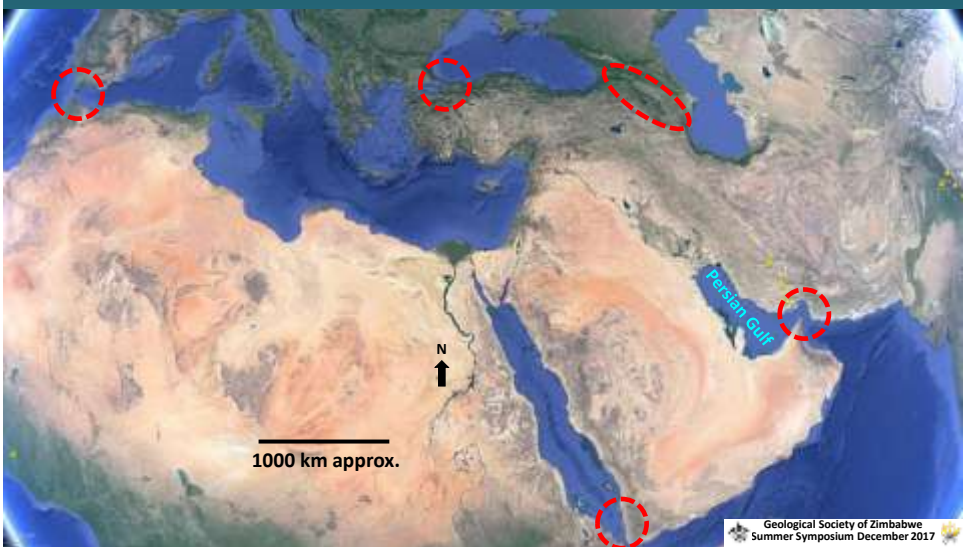
Bonneville Salt Flats / Salton Sea / Sea of Galilee / Etosha & Magadikgadi Pans

ORIGIN OF EVAPORITES

Marine basins

Marine basins – none today but potential

Mediterranean, Black and Caspian Seas / Red Sea / Persian Gulf



ORIGIN OF EVAPORITES

Marine basins

Epicontinental basins – none today but potential

Mediterranean, Black and Caspian Seas / Red Sea / Persian Gulf

ORIGIN OF EVAPORITES

Marine basins

Epicontinental basins – none today but potential

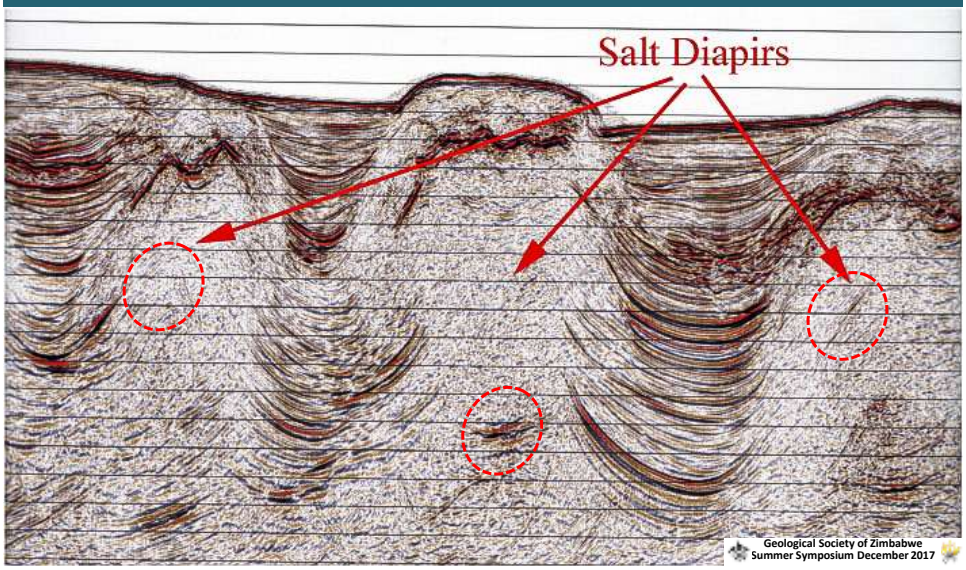
Mediterranean, Black and Caspian Seas / Red Sea / Straights of Hormuz

DIAPIRS IRAN

Salt Diapirs

Salt walls

SALT DIAPIRS



DIAPIRS IRAN

Features – flow banding

DIAPIRS IRAN

Features – wall rock inclusions

DIAPIRS IRAN

Features – salt glaciers

DIAPIRS IRAN

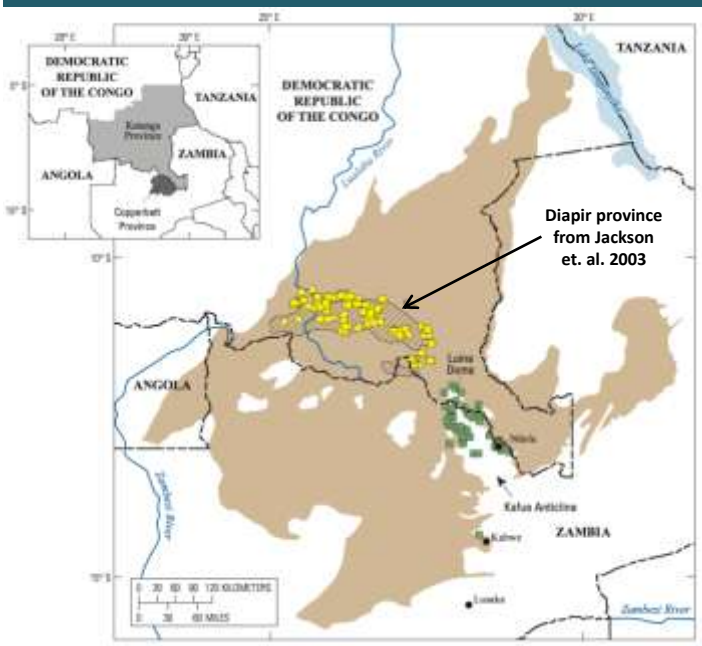
Visa issues ??!!!

DIAPIRS IRAN

DIAPIRS IRAN & CHINA

Wall rock inclusions

CENTRAL AFRICAN COPPERBELT



CENTRAL AFRICAN COPPERBELT

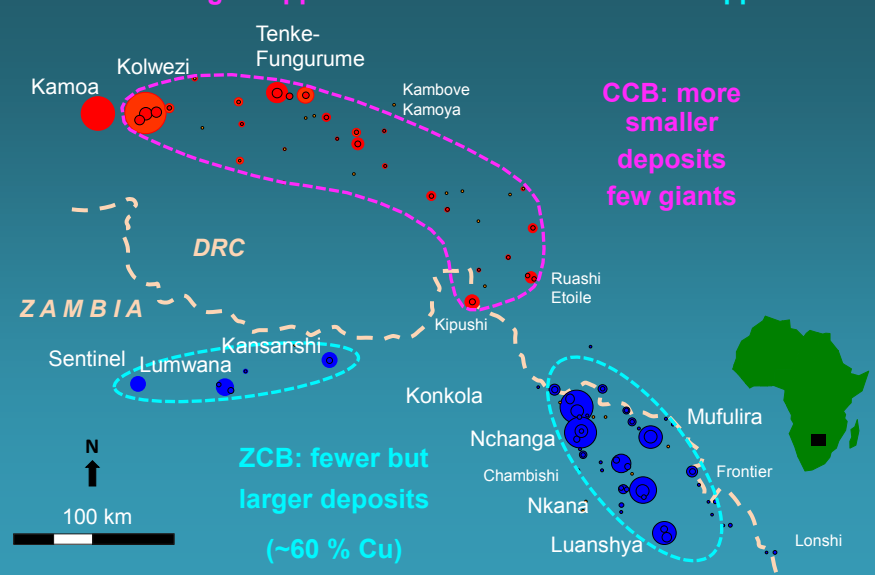
Neoproterozoic allochthonous salt tectonics during the Lufilian orogeny in the Katangan Copperbelt, central Africa

Jackson M.P.A., Warin O.N., Woad G.M. and Hudec M.R.
Bureau of Economic Geology,
The University of Texas at Austin, Austin, Texas

CACB Central African Copper Belt

CCB Congo Copper Belt

ZBC Zambian Copper Belt



CCB: more smaller deposits few giants

ZCB: fewer but larger deposits (~60 % Cu)

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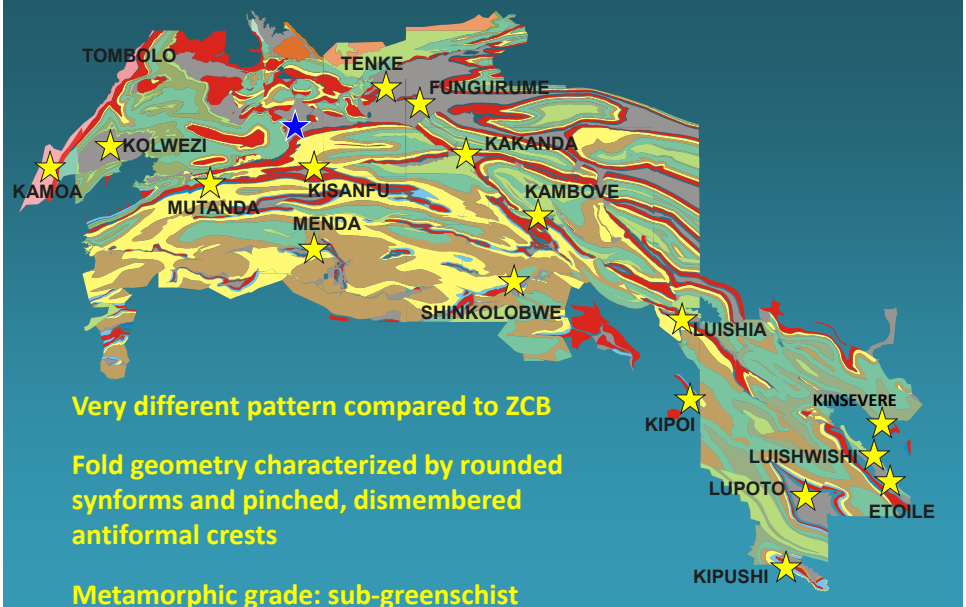
CCB GEOLOGY



Very different pattern compared to ZCB

Fold geometry characterized by rounded synforms and pinched, dismembered antiformal crests

Metamorphic grade: sub-greenschist

IRAN STRUCTURE

Horizontal tight folds dismembered antiforms – not dissimilar to CCB

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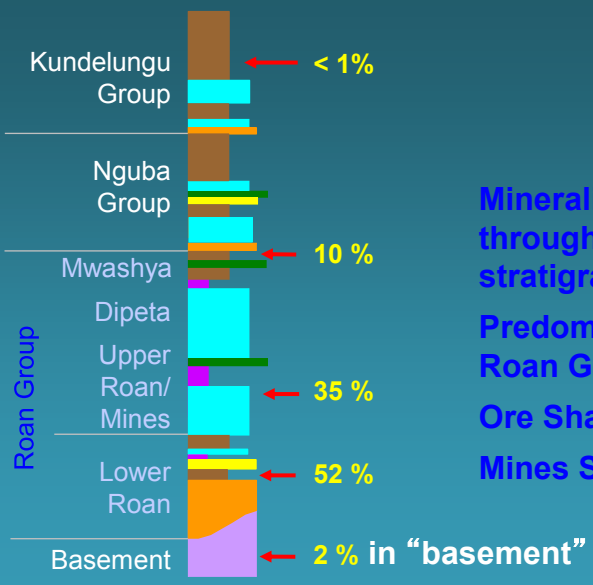
CACB Stratigraphic Distribution of Copper

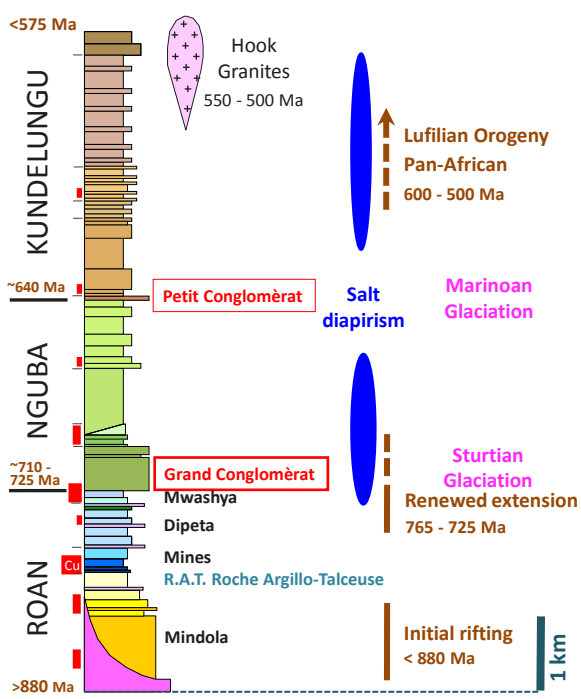


Mineralisation throughout the stratigraphy but…

Predominantly (>90%) in Roan Group

Ore Shale Zambia

Mines Series DRC



CACC Stratigraphy

Katangan Supergroup ~5-6 km thick (present day)

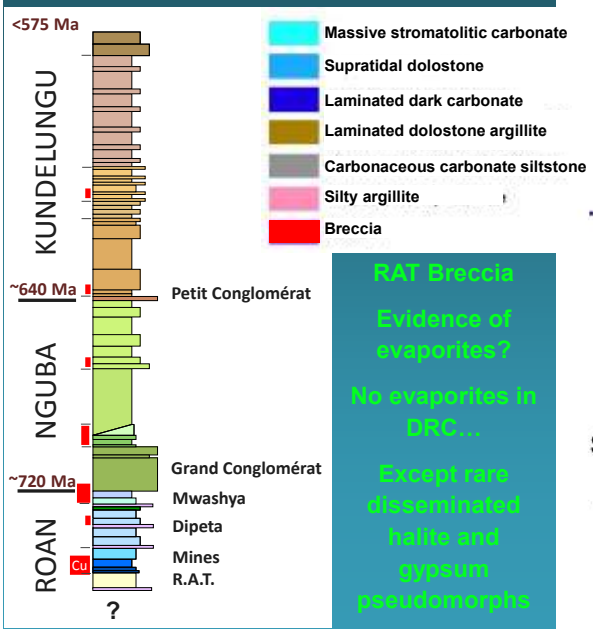
Ages poorly constrained > 880 – 575 Ma (~ 300 Ma)

Very thin sequence for amount of time – significant unconformities?

Global correlation based on glaciogenic diamictites "Snowball Earth"

Complex history of extension prior to basin inversion / orogeny and metamorphism

CCB Stratigraphy

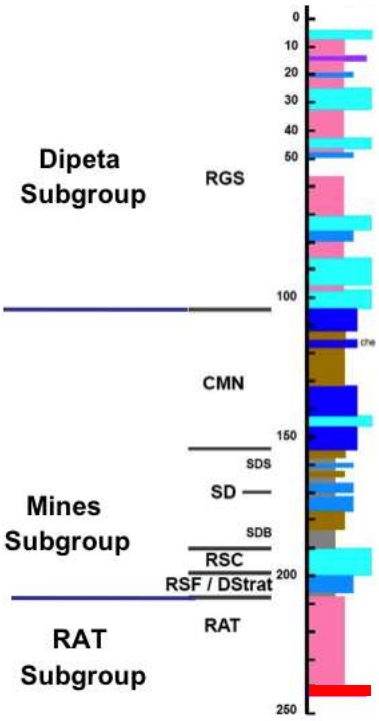


RAT Breccia

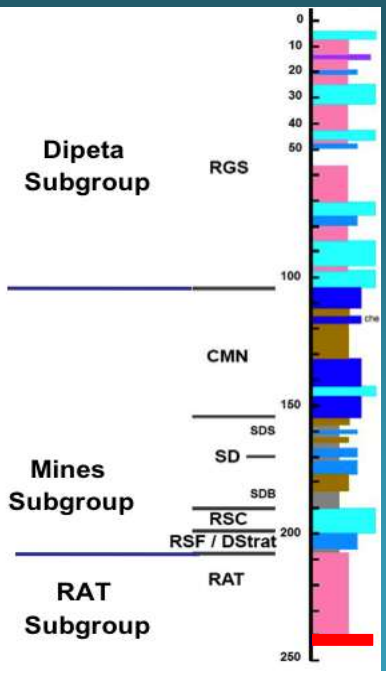
Evidence of evaporites?

No evaporites in DRC…

Except rare disseminated halite and gypsum pseudomorphs



CCB Stratigraphy



- Massive stromatolitic carbonate
- Supratidal dolostone
- Laminated dark carbonate
- Laminated dolostone argillite
- Carbonaceous carbonate siltstone
- Silty argillite
- Breccia

Roan Supergroup base not seen in CCB

RAT fine- to medium-grained red beds

Dominant mineralised host Mines Subgroup but…

Only as blocks / écailles in megabreccias

Central African Copperbelt

Structure within the CACB reflects:

Early rifting (Lower Roan and Upper Roan-Mwashya times)

Salt tectonics initiated in lower Nguba time through mid-Kundelungu and maybe again during Lufilian

Lufilian event probably related to transpressional Pan African collision along the Mwembeshi Shear Zone between the Congo and Kalahari Cratons

Resulting in basin inversion with renewed salt tectonics and northward directed gravity sliding, local folding and thrusting.

CACB — Mineralisation

Copper Source – **Red beds (oxidised) R.A.T. and probably basement**

Sulphur source – **Diagenetic sulphate and evaporites and minor diagenetic pyrite**

Oxidation state – **Metal complexes stable in oxidising solutions**

Reductant trap – **Organic matter (reducing) black shales / siltstone / sandstone and minor diagenetic pyrite and…**

Migrated hydrocarbons gas /oil indicated by carbon isotope values

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CACB — Mineralisation

Central African Copperbelt

- CACB a "closed" system – residual basinal brines trapped in lower sequences initially beneath an evaporite cap
- Widespread alteration (K, Mg-Si, Na) due to high salinity, oxidised brines
- Sulphide mineralization in specific reducing lithologies and structures – sulphide precipitation due to redox change
- Long period of mineralisation – recirculating fluids

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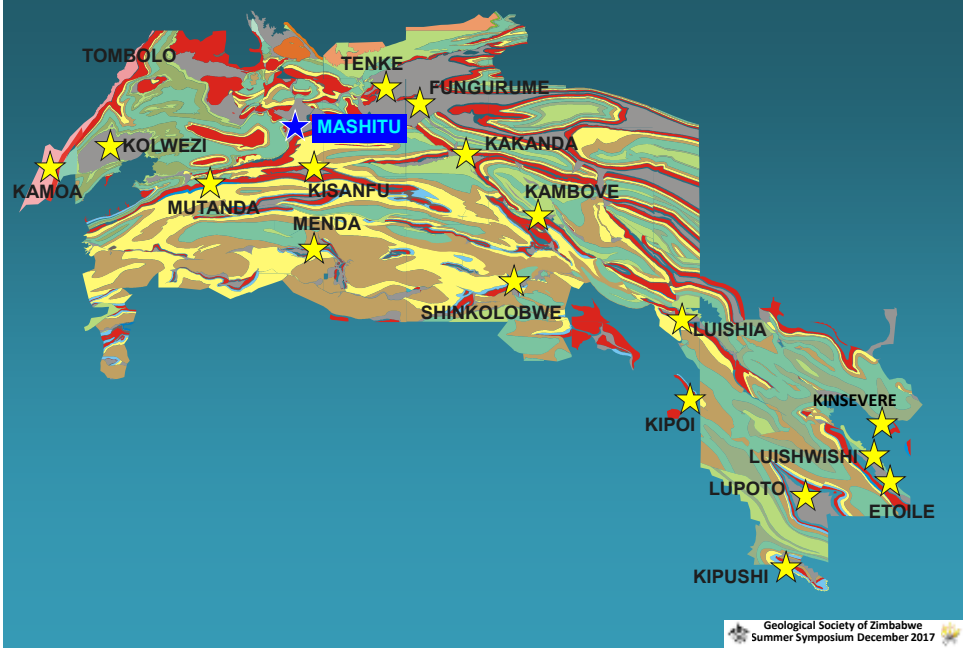
CCB GEOLOGY AND THE MASHITU AND OTHER BRECCIAS



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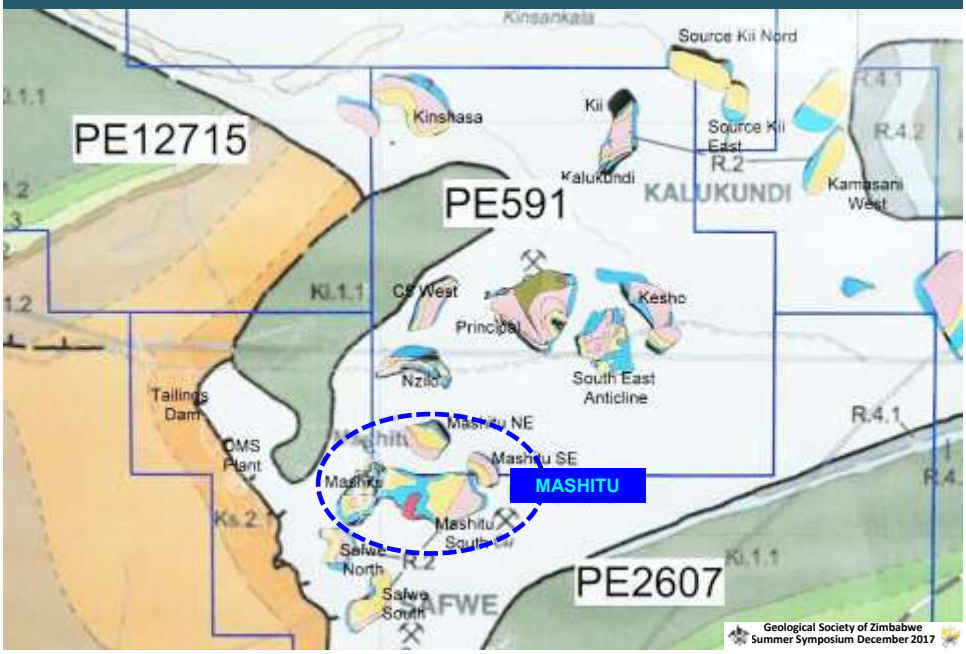
CCB BRECCIAS MASHITU



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CCB GEOLOGY AND THE BRECCIAS

RAT characteristics

Mainly homogeneous red to purple and grossly layered with sedimentary bedding but bedding only locally well defined

Layering deformed – open horizontal folds but…

Suggestions of isoclinal folding

Very low grade metamorphism

Mineralogy:

Major: haematite, quartz, Kspar, Mg-chlorite, and phengite

Minor: dolomite, magnesite, talc, albite, accessory rutile, ilmenite, apatite

Abnormal composition – metasomatised and/or depleted?

CCB GEOLOGY AND THE BRECCIAS

Breccia characterisation – internal characteristics

Widely variable clasts:

- Composition – but not always
- Size
- Angularity

Widely variable matrix:

- Similar composition to clasts? or…
- Very different from clasts?

Widely variable clast/matrix ratios

Therefore different breccia types but…

Two main types: monomict and polymict

Breccia characterisation – shape of breccia bodies

- Mostly irregular
- Some roughly tabular
- Some intrusive conical or wedge-shaped
- Evidence of breccia clasts in breccia and
- Breccia intruding breccia
- 'Fold' structures may be breccia intrusions
- Derived from RAT – do others have a different provenance?

Breccia matrix characteristics

Two types

- Monomict breccia
- Polymict breccia

Oxide (hematite) alteration associated with monomict breccias

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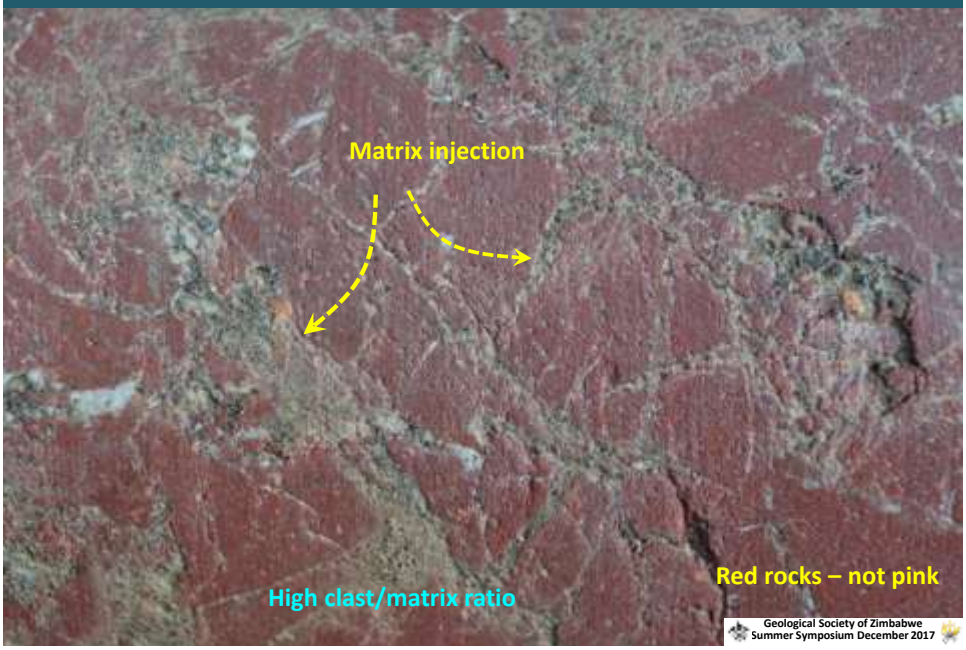
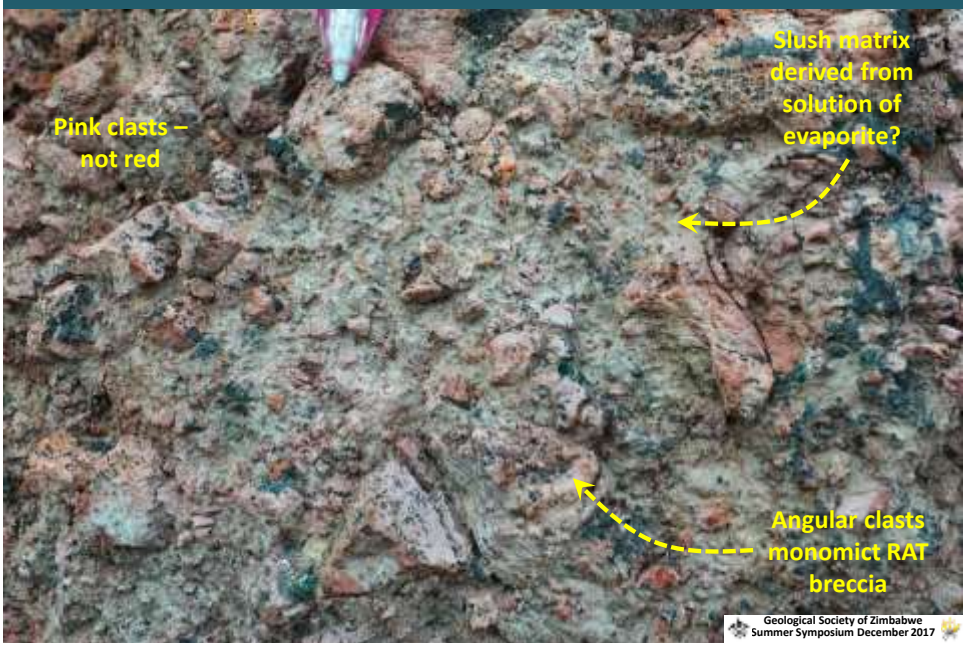
MONOMICT BRECCIAS MENDA



MONOMICT BRECCIAS MASHITU

MONOMICT BRECCIAS MASHITU



MONOMICT BRECCIAS KAKANDA

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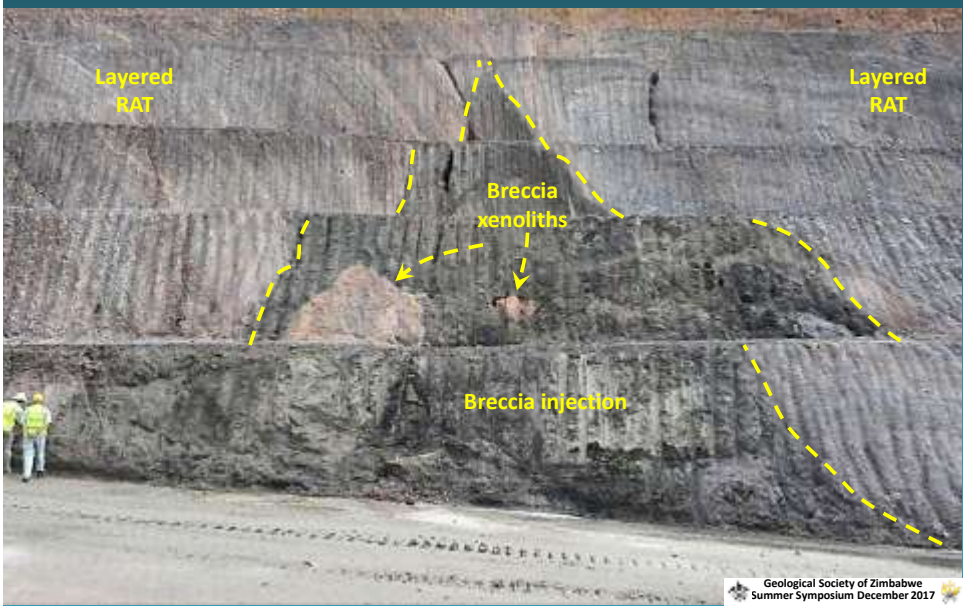
MONOMICT BRECCIAS KAKANDA

MONOMICT BRECCIAS MASHITU



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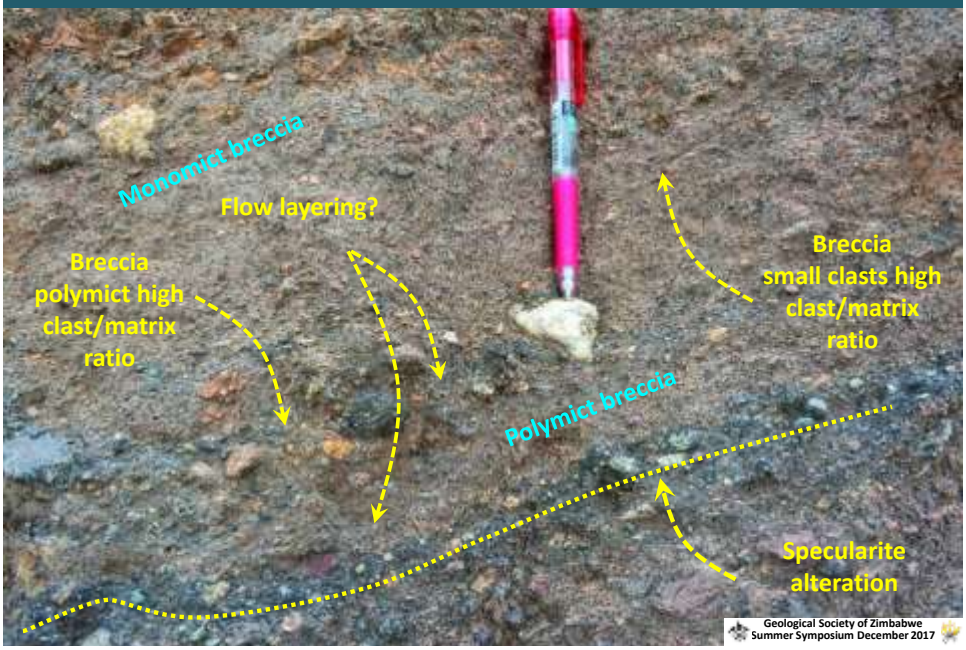
CCB BRECCIAS MASHITU



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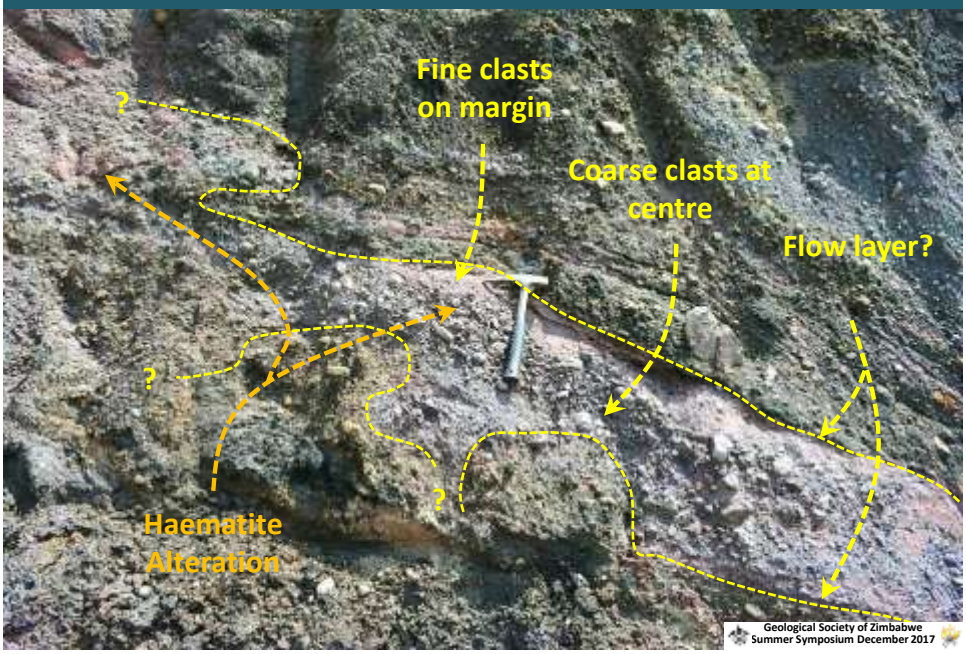
RAT Breccia

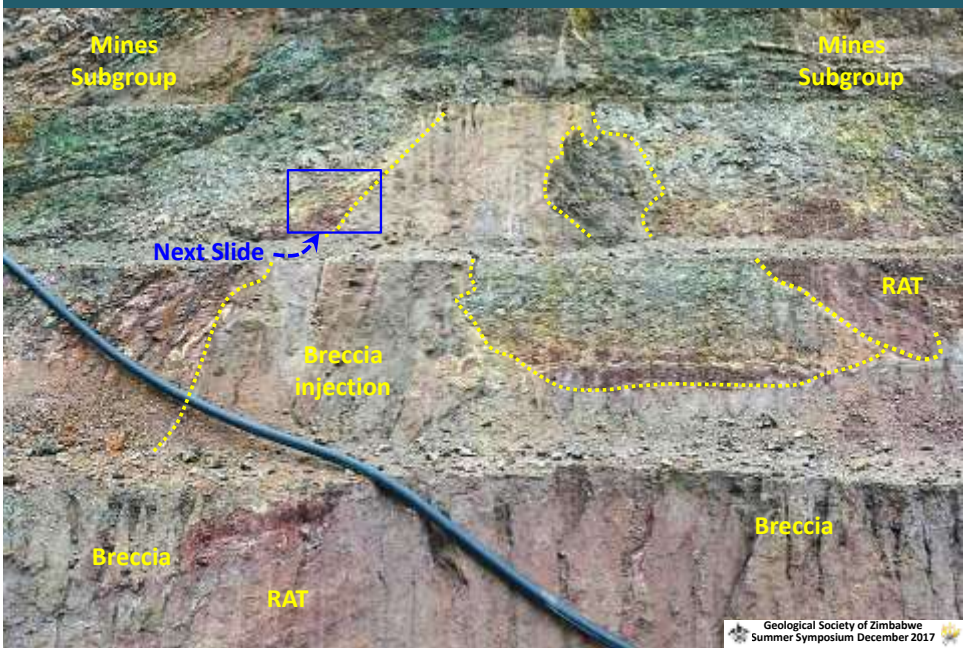


RAT breccia and layering

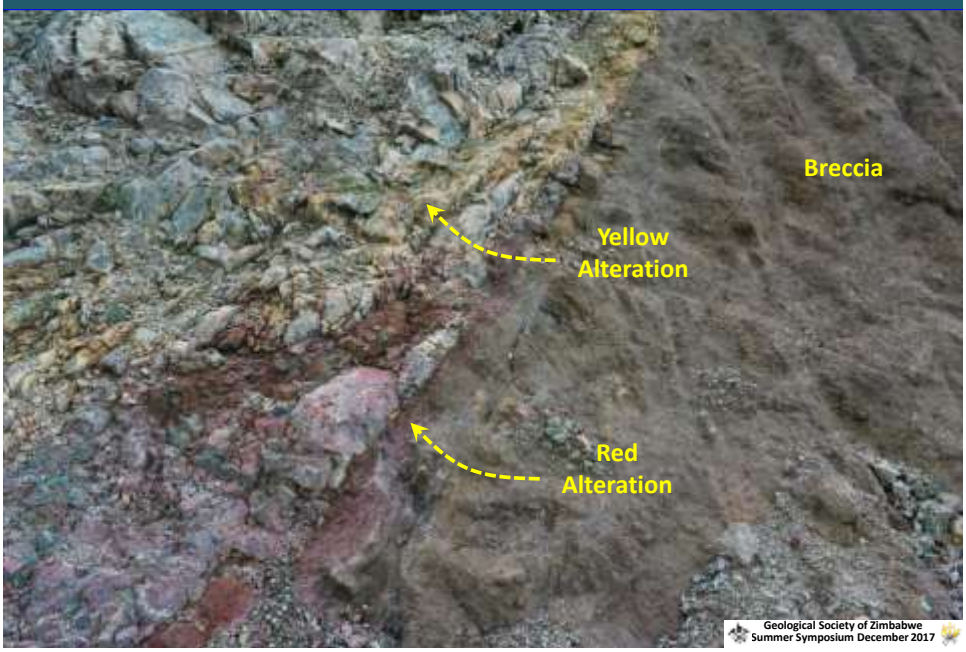
RAT breccia and layering

RAT Breccia types

RAT Breccia west wall



RAT Breccia and Mines rocks west wall



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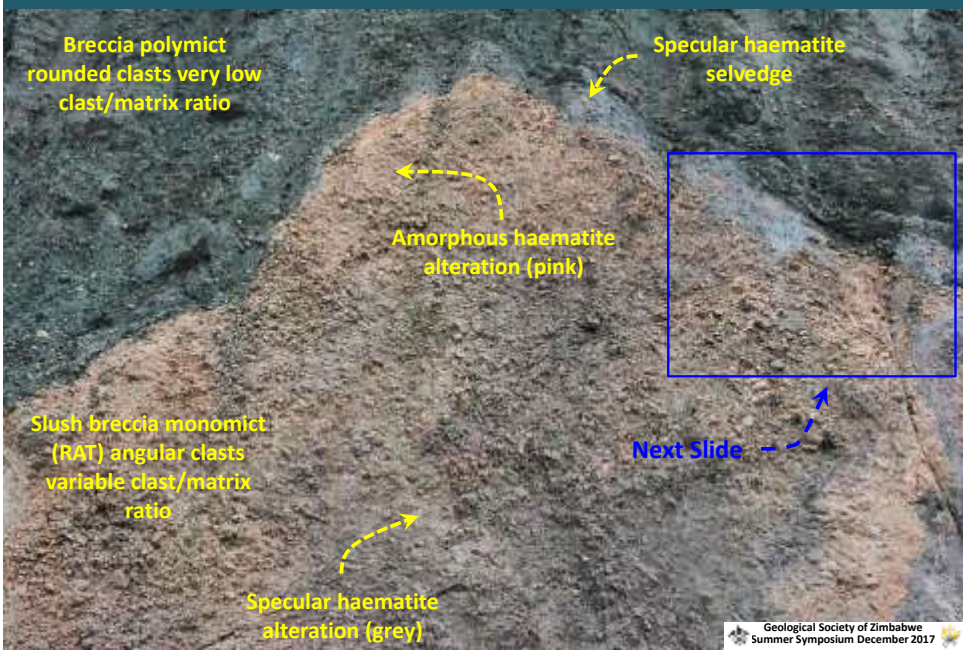

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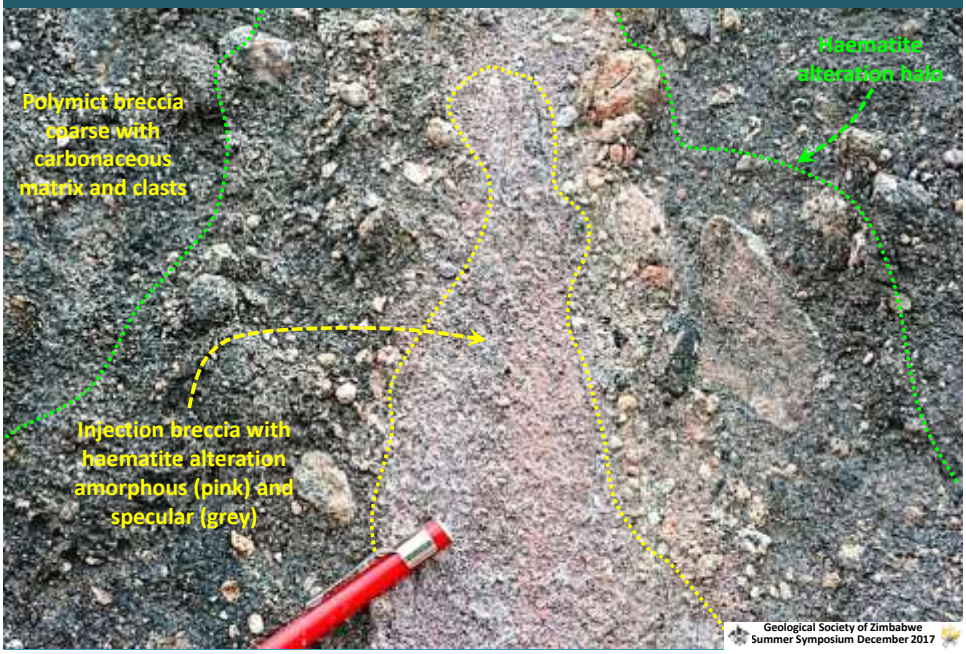

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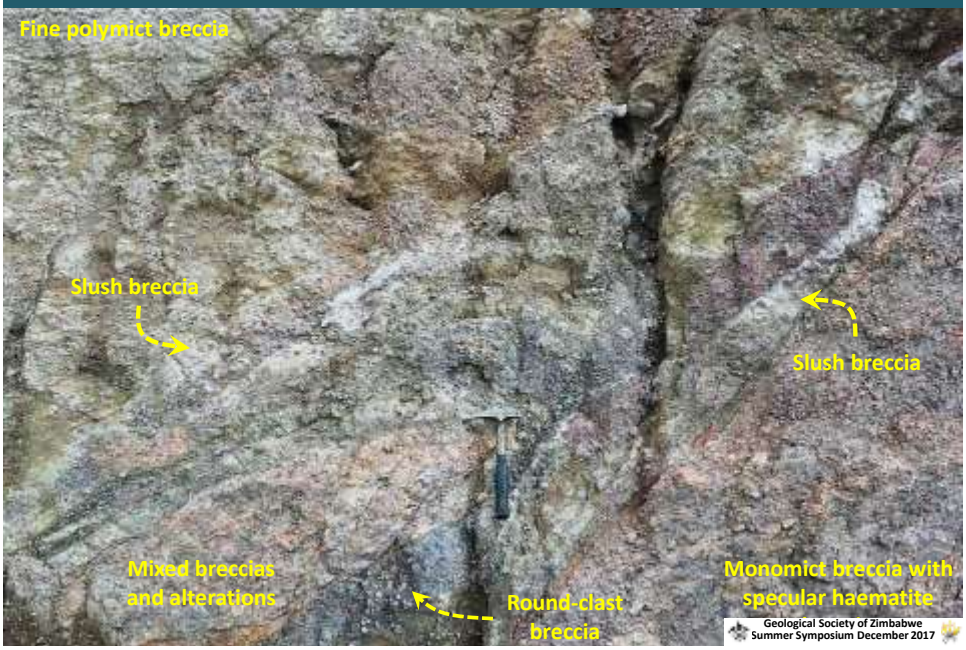

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CCB BRECCIAS MASHITU

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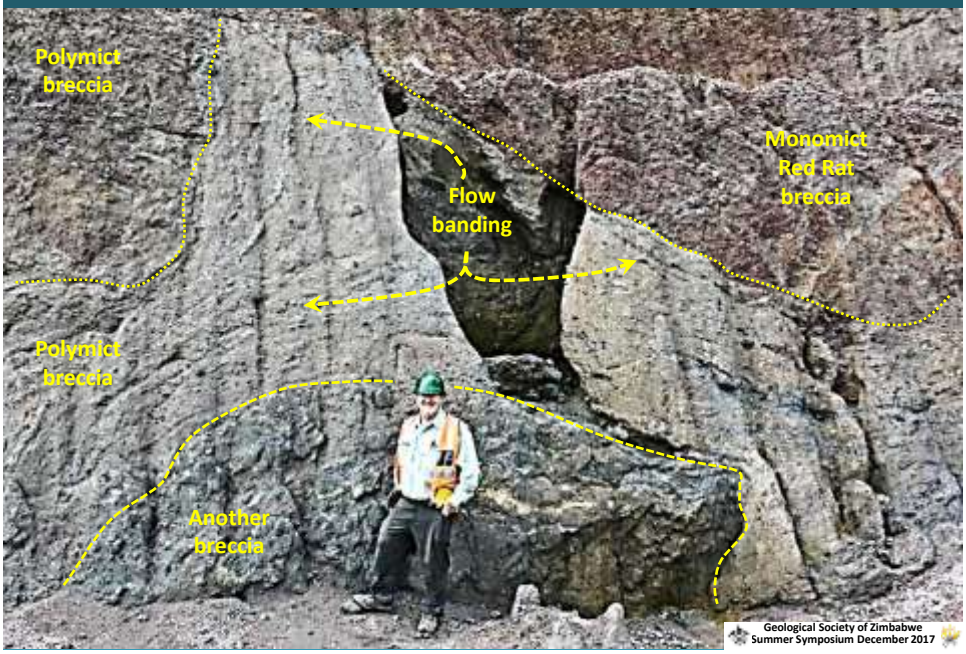

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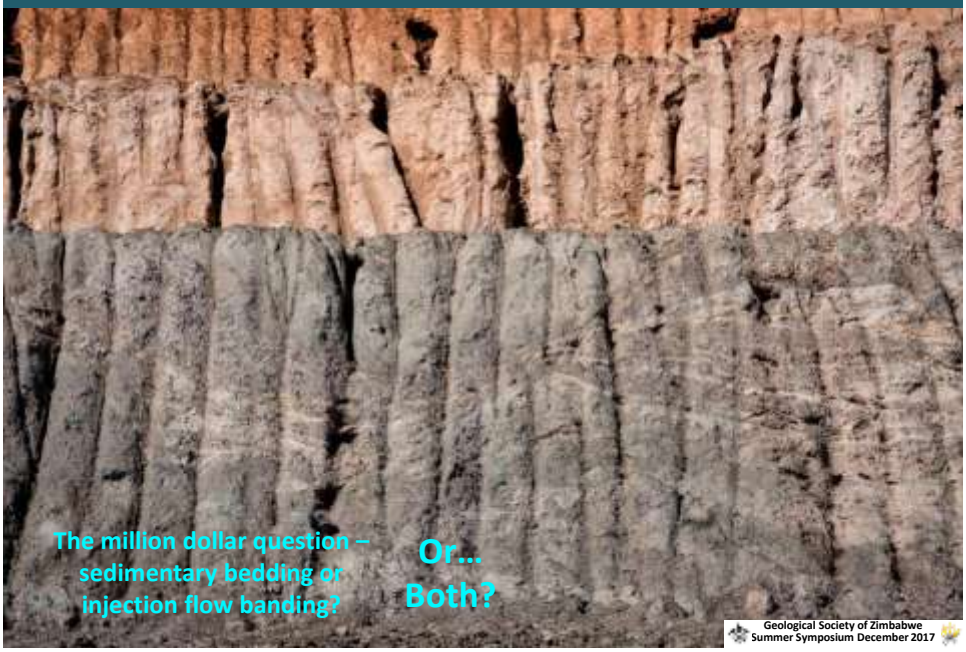

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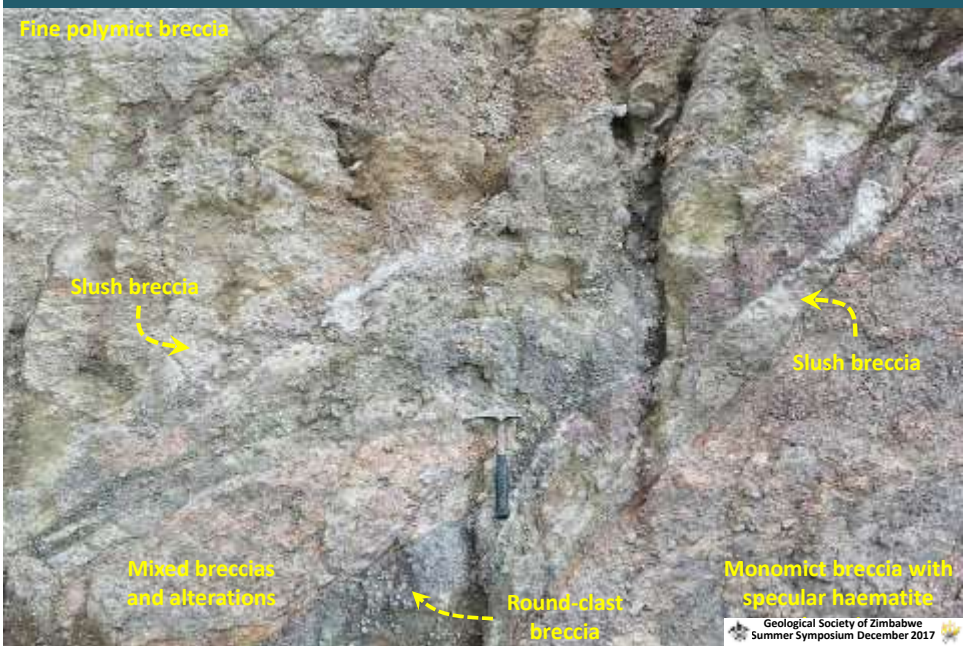
CCB BRECCIAS MASHITU

CCB BRECCIAS MASHITU

Multiple breccia bodies and alterations



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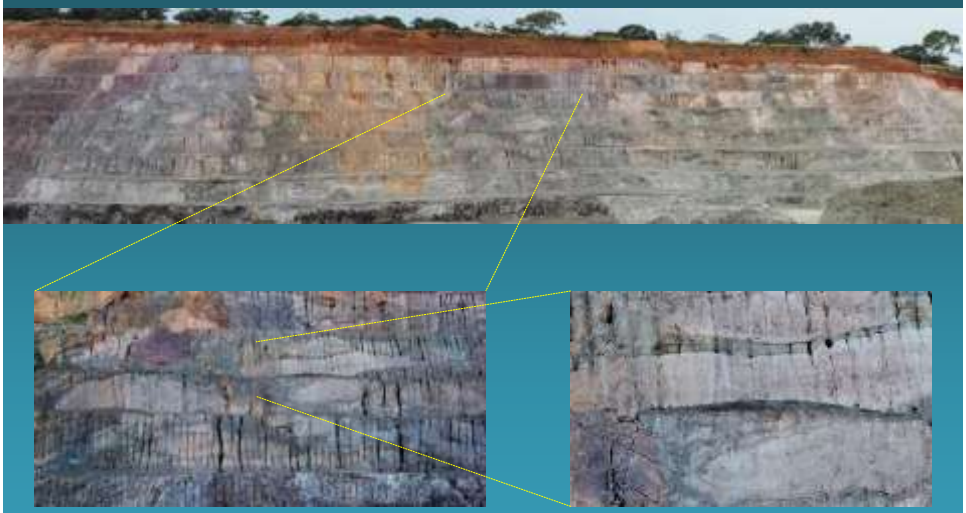
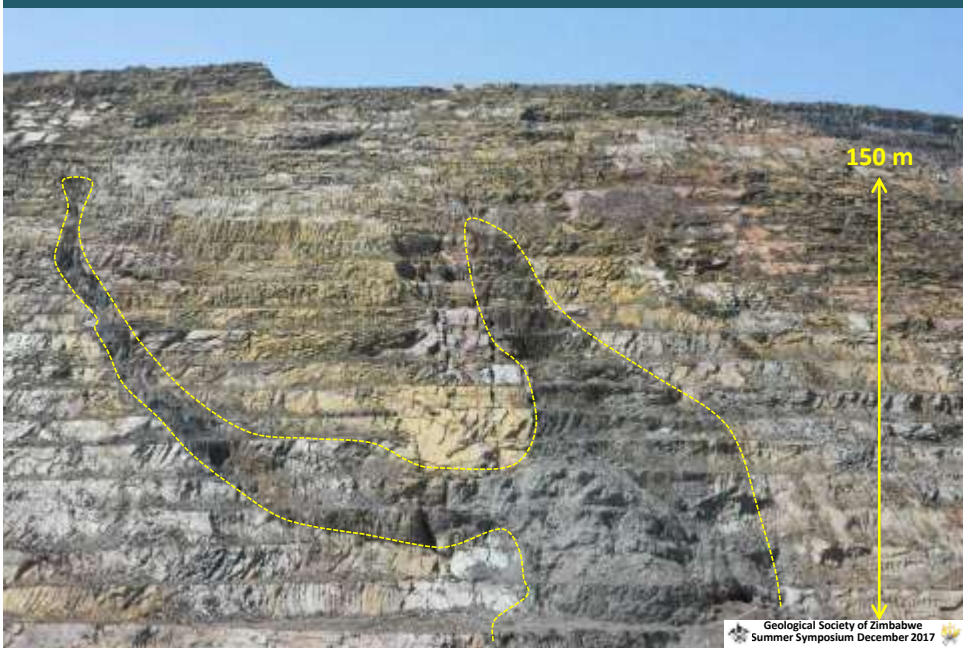
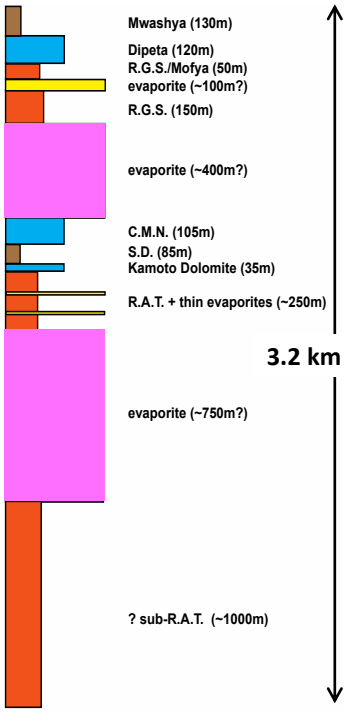


CCB BRECCIAS MUKONDO





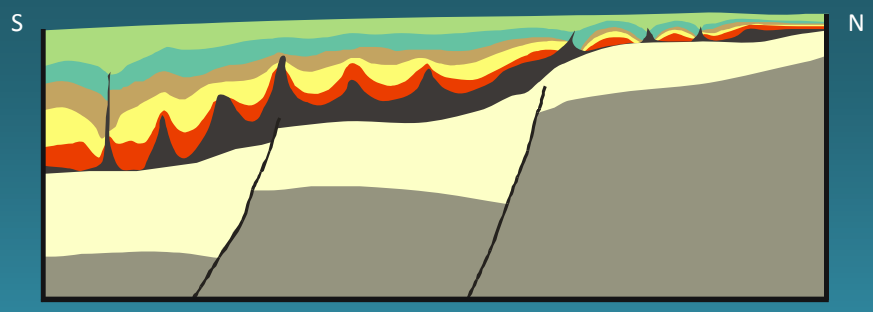
CCB Roan Stratigraphy with evaporites (based on Tenke-Fungurume)

Evaporites probably formed the bulk of the RAT

RAT red beds next most common

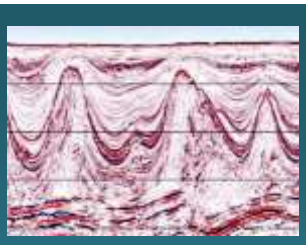
Mineralised carbonate / shale beds are thin

CCB fold style



Fold probably rounded synforms and pinched, dismembered antiformal crests – typical of halokinesis

Anticlines occupied by megabreccia with large (up to >1 km size) blocks in an argillaceous, sometimes talc-rich matrix



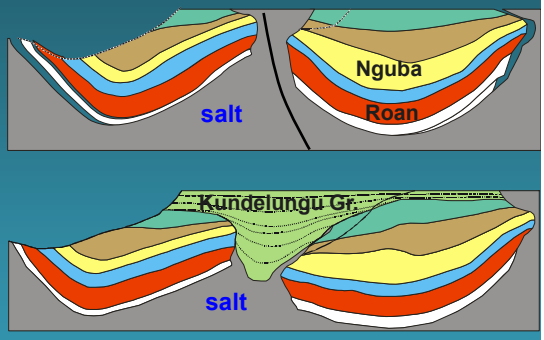
CCB Structural Patterns are Indicative of Salt Tectonics (Halokinesis)

Salt located in the Roan Group

Passive diapirism triggered by diamictite loading produced salt walls and domes

Thickness changes in Nguba and lower Kundelungu groups suggest diapirism started then

Late sedimentary basins filled in the space (Kundelungu Group) — salt dissolution?



Diapirism nucleated along syn-rift normal faults and propagated through Nguba but…

THERE IS NO SALT IN THE CCB

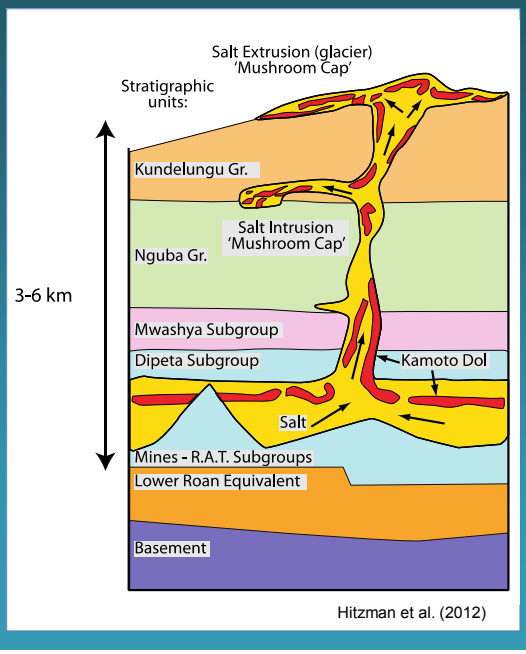
Diapiric Breccias in the CCB

Salt breaks through and incorporates wall rocks during ascent

Movement grinds the fragments and rounds them to produce durchbewegung textures

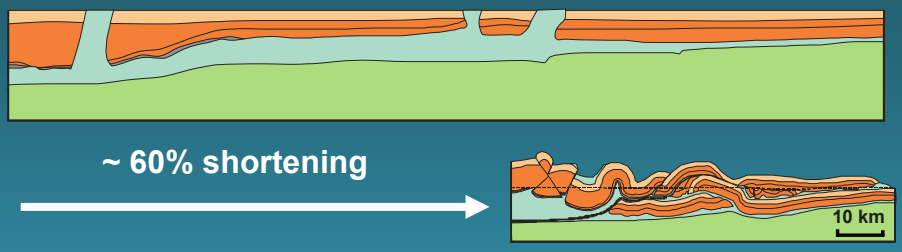
Subsequent dissolution of the salt causes collapse of the incorporated (and rounded) rock fragments which fall to the bottom of the space previously occupied by the salt

The collapse and Lufilian tectonics squeezed the slush breccia into any available orifice



Hitzman et al. (2012)

Salt Tectonic Model for the CCB (60% Shortening) — Modified from Jackson et. al. 2003



Thick evaporite deposition in one or more layers within the Roan Group

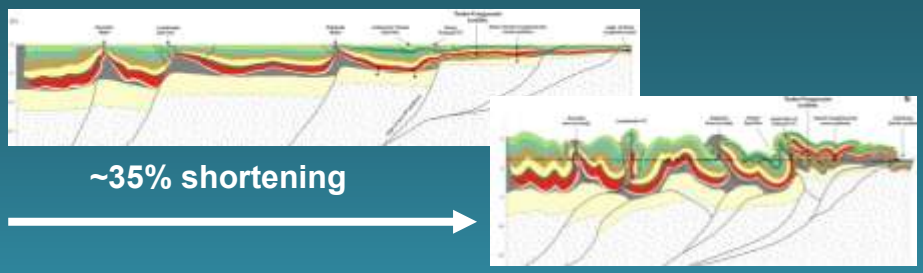
Halokinesis initiated when buried (~ during Grand Conglomérat deposition)

Upper stratigraphic levels split by salt diapirs and walls

Basin inversion during the Lufilian driven by compression to south

Model does not address geology on the southern margin of the basin

Salt Tectonic Model for the CCB (35% Shortening) — Selley et. al. 2010



Thick evaporite deposition in one or more layers within the Roan Group

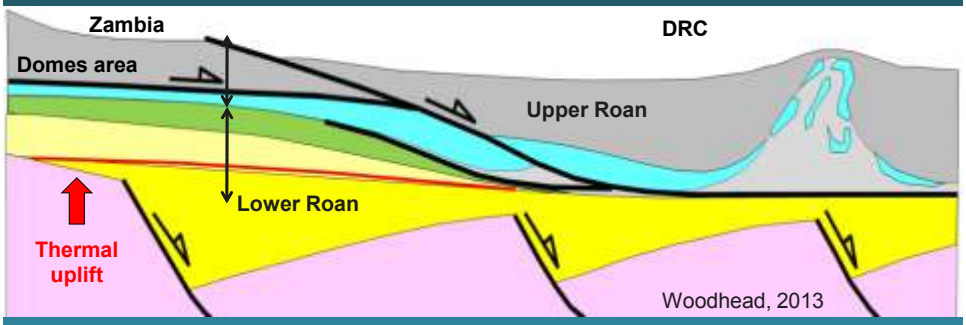
Halokinesis initiated when buried (~ during Grand Conglomérat deposition)

Upper stratigraphic levels split by salt diapirs and walls

Early basin extension normal faults form loci of antiformal, breccia-cored salt diapirs

Late basin inversion during Lufilian influenced by original basin configuration and salt tectonism

Gravity Sliding into the Katangan Basin



Selley et al. (2010) model assumed thrusting of basement over the southern edge of the Katangan basin – a purely compressional event

Hitzman invoked thermal uplift of southern Domes area induced gravity sliding lubricated by evaporites

The thermal event at ~530 Ma contemporaneous with the Hook "granite" event — intrusion of numerous intermediate plutons to south of Domes region

My contention is that the slush breccias provided the lubrication and not the salt – "toothpaste tectonics"