東華理工大學
EAST CHINA INSTITUTE OF TECHNOLOGY

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Granite-related Hypothermal Uranium Mineralization in South China

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1. Clssification of U Deposits in China

IAEA 2013 new classification: 15 types with 36 subtypes

1）Intrusive
2）Granite-related
3）Polymetallic iron-oxide breccia complex （IOCG）
4）Volcanic-related
5）Metasomatite
6）Metamorphite
7）Proterozoic unconformity
8）Collapse-breccia pipe
9）Sandstone
10）Paleo-quartz-pebble conglomerate
11）Surficial
12）Lignite-coal
13）Carbonate
14）Phosphate
15）Black shale

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1. Clssification of U Deposits in China

On the basis of host rocks, the uranium deposits were traditional classified into four major types:

1) Granite type & Granite-related (endogranite)

2) Volcanic rock type & Volcanic-related (structure-bound)

3) Sandstone type & Sandstone (roll-front/tabular)

4) Carbonaceous-siliceous- argillaceous rock type

&

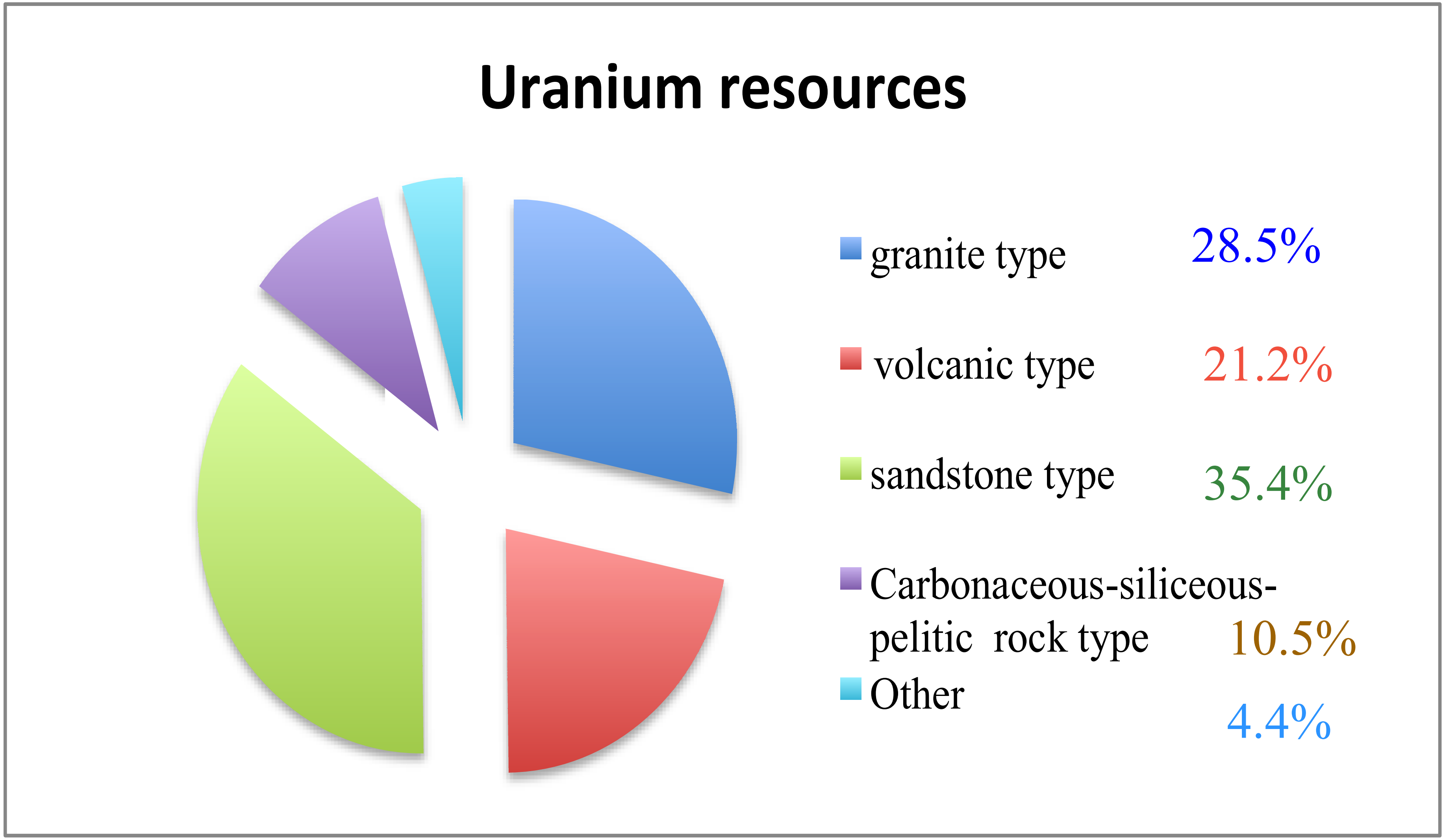
Carbonate or black shale type

5) Other type

No typical Proterozoic unconformity and Paleo-quartz-pebble conglomerate type deposits up to now.

(New suggestion on classification- Zhang, 2012, Li, 2013)

Shares of different type uranium deposits



2. Metallogenic Region Subdivisions for Uranium Deposits

According to geological setting and the spatial distribution of different type uranium deposits:

The metallogenic region subdivisions were previously divided into:

5 uranium provinces

18 metallogenic regions / belts

in 3 regional geological domains

2. Metallogenic Region Subdivisions for Uranium Deposits

New subdivisions (BOG, CNNC, 2012):

4 uranium metallogenic domains:

a, Paleo-Asian **b, Qin-Qi-Kun**

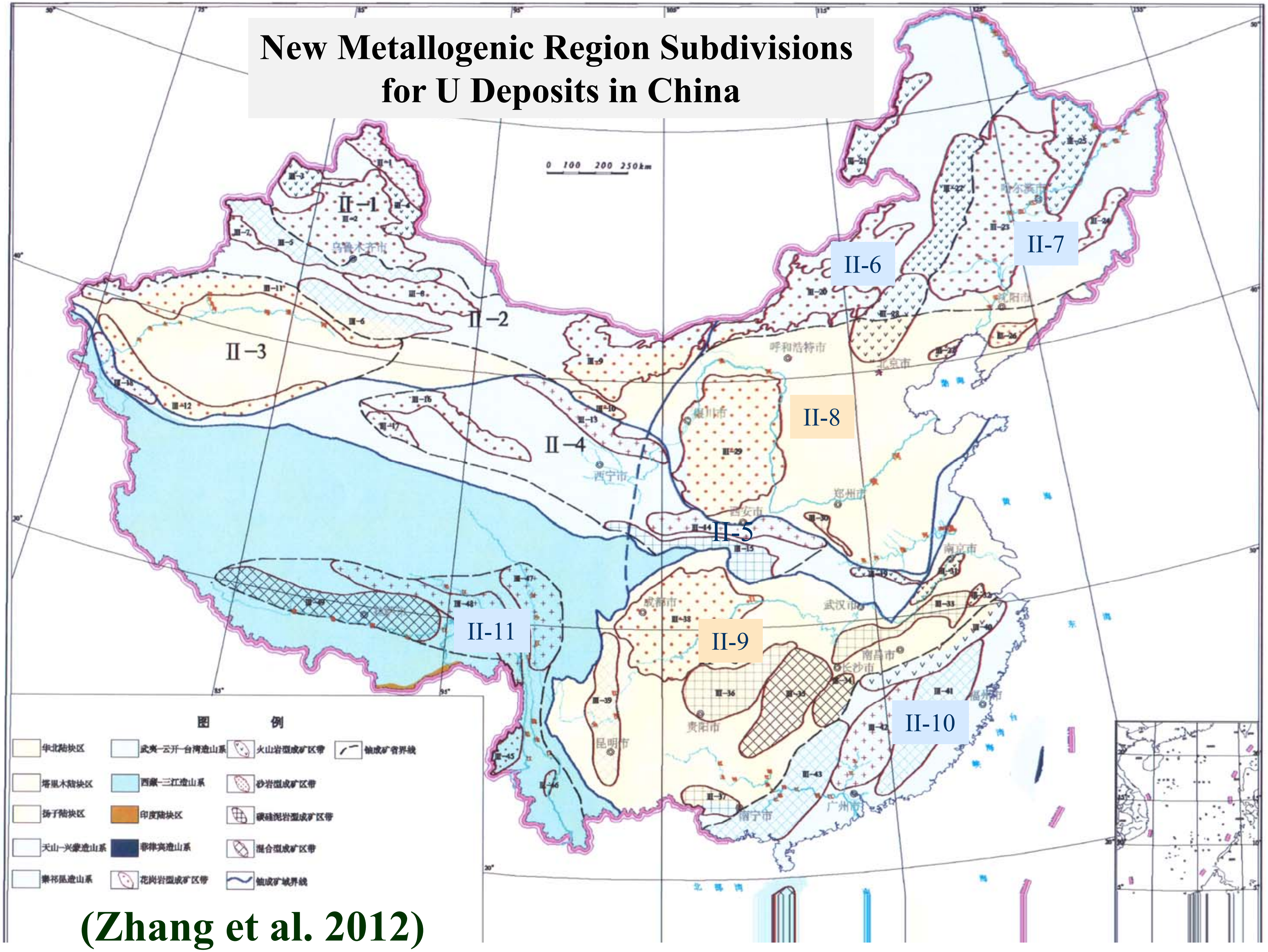
c, Marginal-Pacific **d, Tethys**

11 uranium provinces

49 metallogenic regions / belts

Most of the discovered U deposits located in Marginal-Pacific domains with the mineralization age of Mesozoic- Cenozoic.

New Metallogenic Region Subdivisions for U Deposits in China

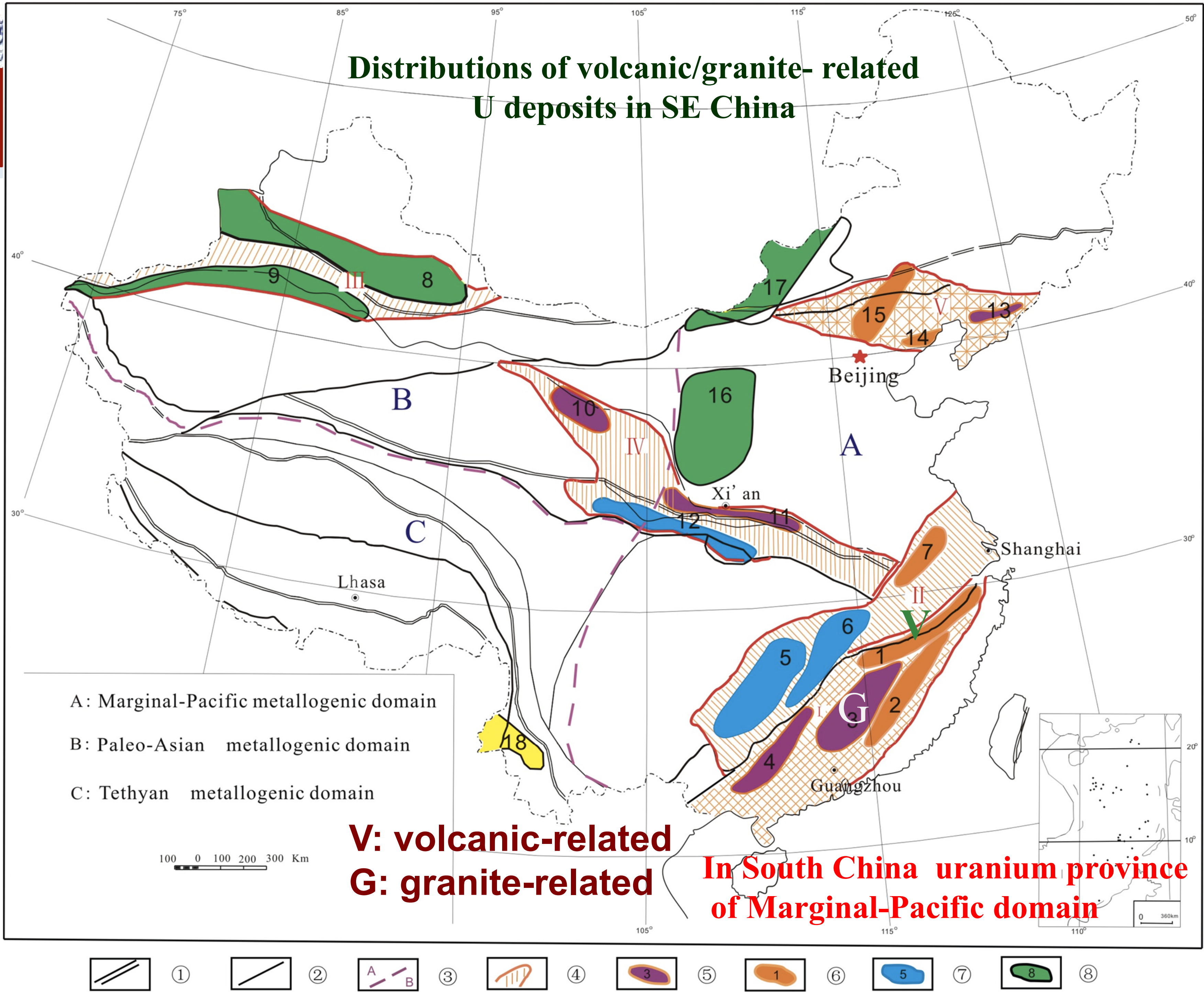


(Zhang et al. 2012)

Domain	No. of Province	Name of province	Region/ Belt
Paleo-Asian	II-1	Aertai-Zhungeer	III-1 Aertai potential belt
			III-2 Zhungeer potential region
			III-3 Xuemisitan potential belt
			III-4 Wurunguhe potential belt
	II-2	Tianshan	III-5 North Tianshan potential belt
			III-6 South Tianshan belt
			III-7 Yili basin region
			III-8 Tuha basin region
	II-3	Talimu	III-9 North Talimu belt
			III-10 South Talimu potenitial belt
Qin-Qi-Kun	II-4	Qinqi-Kunlun	III-11 West Kunlun potential belt
			III-12 Qimantage potential belt
			III-13 Talimu basin potential region
			III-14 Longshoushan-Qilianshan belt
	II-5	Qinling-Dabie	III-15 South Qinling belt
			III-16 North Qinling belt
			III-17 Jingzai belt
Marginal-Pacific	II-6	Daxinganling	III-18 Erlian basin region
			III-19 Badanjilin-Bayinggebi region
			III-20 Eerguna-Manzhouli potential belt
			III-21 Zalantun potential belt
	II-7	Jihei	III-22 Songliao basin region
			III-23 Dunhua-Mishan potential belt
			III-24 Yichun potential belt

Domain	No. of Province	Name of province	Region/ Belt
Marginal-Pacific	II-8	North China Craton	III-25 East Liaoning belt
			III-26 Xincheng-Qinglong belt
			III-27 Guyuan-Hongshanzi belt
			III-28 Ordos basin region
			III-29 Chaoshui basin region
			III-30 South Margin of North China Craton belt
	II-9	Yangzi Craton	III-31 Middle and lower reaches of Yangtze River belt
			III-32 Tianmushan belt
			III-33 Xiushui-ningguo belt
			III-34 Middle Hunan belt
			III-35 Xuefeng-Mutianling Belt
			III-36 Middle Guizhou-Northwest Hunan belt
			III-37 Damingshan belt
			III-38 Sichuang basin region
			III-39 Kham-Dian（West Sichuan-Yunnan） Axis potential belt （IOCG type?）
	II-10	South China	III-40 Gang-Hong belt
			III-41 Wuyishan belt
			III-42 Taoshan-Zhuguang belt
			III-43 Chengzhou-Qingzhou belt
			III-44 Leming basin potential region
Tethys	II-11	Gangdisi-Sanjiang	III-45 Tengchong region
			III-46 Linchang region
			III-47 Duchang potential belt
			III-48 Bange-Jialing potential belt
			III-49 Chuoqing-Nanmulin potential belt

Distributions of volcanic/granite- related U deposits in SE China



3. Tectonic Cycle to Uranium Mineralization

In regional:

Mesozoic – Cenozoic **epoch is the most important mineralization age in China.**

In space: 86% discovered ore deposits located in East China marginal-pacific domain.

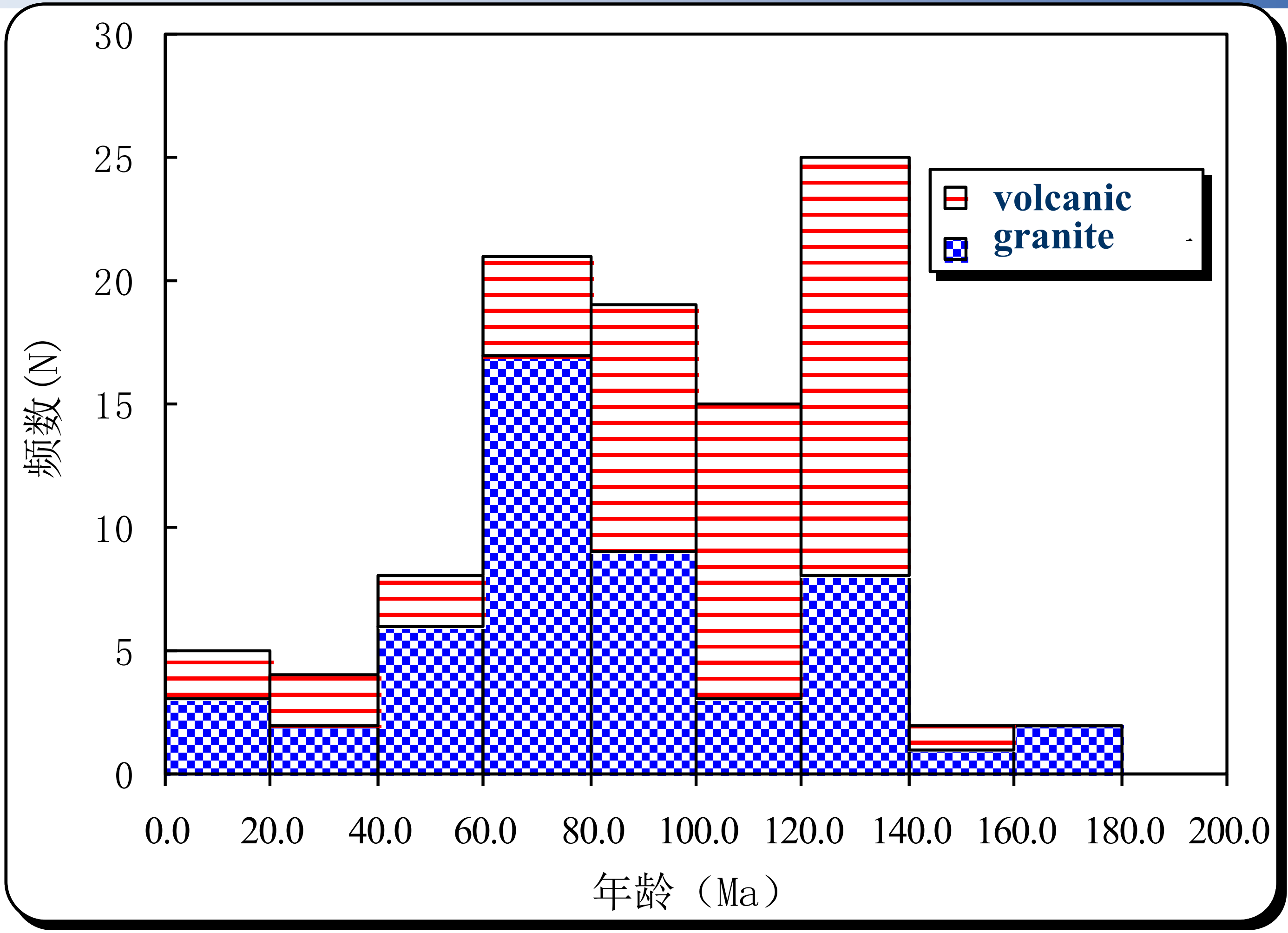
In time: most of the ore deposits formed at the age of 180Ma to 80Ma (Yanshanian epoch)

“ Large-scale metallogenesis age”

----- (Mao et al ,2005)

Granite-related and volcanic-related Uranium mineralization in China share the same characteristics in space& in time.

Number of age data



Age (Ma)

What is the relations of tectonic cycle in Mesozoic- Cenozoic to U mineralization?

3.1 Major tectonic- magmatic stages of Yashanian epoch in SE China

In Ganhang belt:

Two tectonic-magamatic sub-cycles

Stage 1 and 2 of late Yanshanian epoch（145—100Ma）

Stage 3 of late Yanshanian epoch （100—65Ma）

In Taoshan-Zhuguang belt:

Four tectonic-magamatic sub-cycles

Stage 1 of early Yanshanian epoch（205—165Ma)

Stage 2 of early Yanshanian epoch（165—145Ma)

Stage 1 and 2 late of Yanshanian epoch（145—100Ma）

Stage 3 of of late Yanshanian epoch （100—65Ma）

3.2 The relation of tectonic cycles to U mineralization in East China

Tectonic Period	Age(Ma)	Major tectonic-magamtic activities	Geodynamic	Relation to U mineralization
Late Yanshanian epoch Stage 3	100-65 (K_2)	1.depression basins（Erlian Basin） 2.basic and acidic dikes, calc alkalic series	NW-SE extension	1. epithermal U mineralization 2. favorable braided river sedimentary system after the tectonic inversion
Late Yanshanian epoch Stage 2	110-100	1. Tectonic inversion 2. Unconformity between K_2 and K_1	Near SN compression	Favorable near SN extension-ductile faults& fractures by NE left-lateral movement
	125-110 (K_1^2)	1. thick continental lithospheric thinning by extension in East China 2. fault subsidence basin, basin and range tectonics 3. bimodal volcanic rocks, shoshonite, I type and A type granites related to mantle-crust interaction	NW-SE extension	1. hypothermal U mineralization related to porphyry? 2. favorable calc alkalic volcanic-subvolcanic host rocks for U mineralization
Late Yanshanian epoch Stage 1	145-125 (K_1^1)	1.large scale K-rich calc alkalic volcanic-subvolcanic rocks in East China 2. transition of compression tectonics to extension tectonic		
Early Yanshanian Epoch Stage 2	165-145 (J_3)	1. multi-direction convergent orogen, crust lithospheric thickening 2. large scale S type granites 3.transition of near EW tectonics to NE tectonics 4. large scale thrust belts and foreland basins	Multi-direction convergent orogen of three tectonic domains	U-rich S type granites in South China as the favorable host rocks
Early Yanshanian Epoch Stage 1	205-165 （J_1-J_2）	1. J_1-J_2 depression basin 2. J_1-J_2 A type granites and bimodal volcanic rocks in South China 3. tectonic inversion in J_{2z} depression basin	Near SN extension	basin tectonic inversion yielded the favorable sedimentary sequences, such as J_2z formation in Erdos basin
Late Indo-Chinese Epoch	230-205 (T_3)	1. large scale continental block collage, unified Europe – Asia plate 2. near EW orogen, folds in covering and the thrust tectonics 3. S type granites of Indo-Chinese epoch 4. foreland basins（Erdos basin、Sichuang basin）	Continental collision	U-rich S type granite of Indo-Chinese epoch in South China as the favorable host rocks

4. Hypothermal Uranium Mineralization

Two uranium metallogenic systems in SE China ?

Epithermal metallogenic system	Hypothermal metallogenic system
↓	↓
Epithermal mineralization	Hypothermal mineralization

4.1 Characters of epithermal mineralization

Type of ores : vein type

Alteration: silicification, fluoritization

Uranium mineral: pichblende

Mineralization age: < 100Ma

Mineralization T: < 250° C

Gap (H/M): big

Mineralization mechanism: mixing of ancient meteoric water with underground circulation fluids

Gap: *Time gap between host rock and mineralization*

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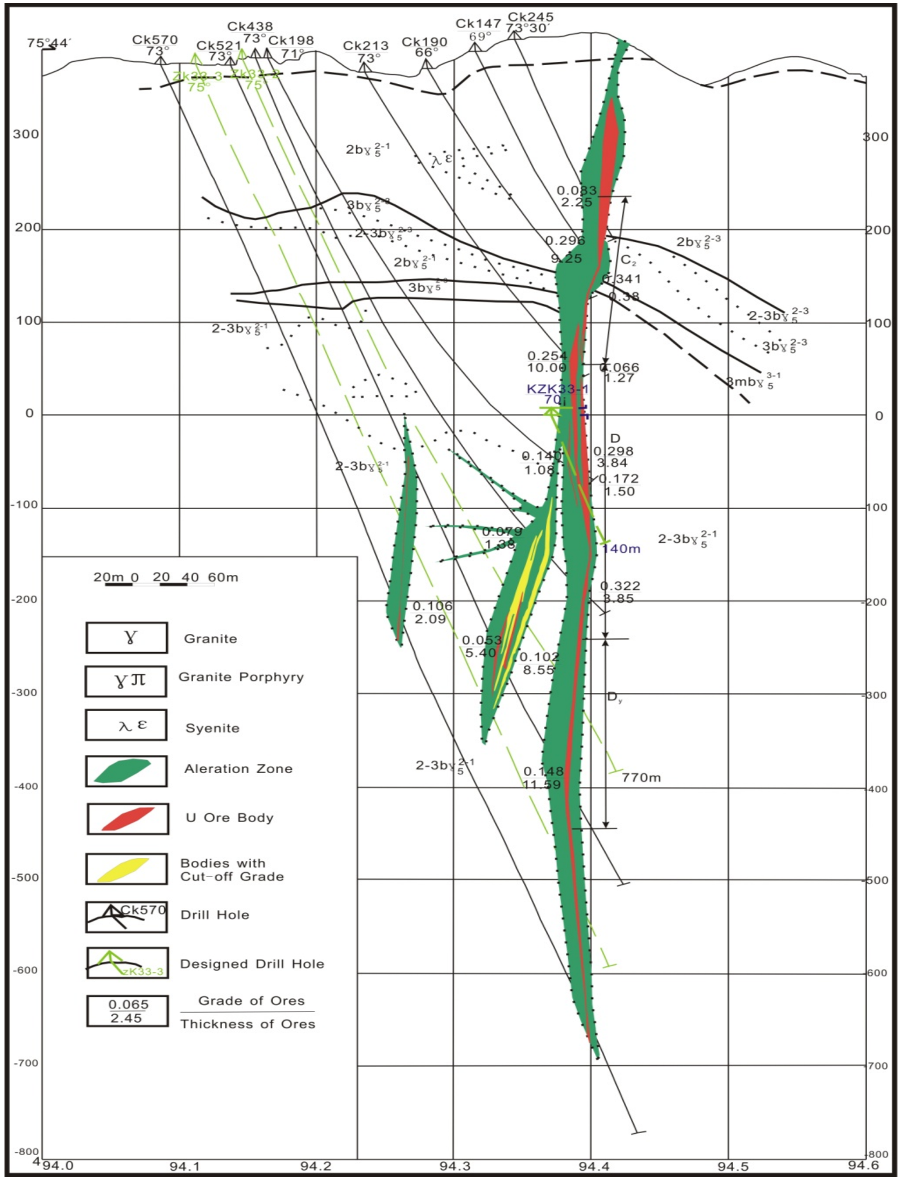
Example： Mianhuakeng Deposit in North Guangdong



Section of Mianhuakeng Deposit

* Endogranitic
* Structure – control

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4.2 Granite-related hypothermal uranium mineralization

In contrast to the characteristics of typical granite-related epithermal uranium mineralization:

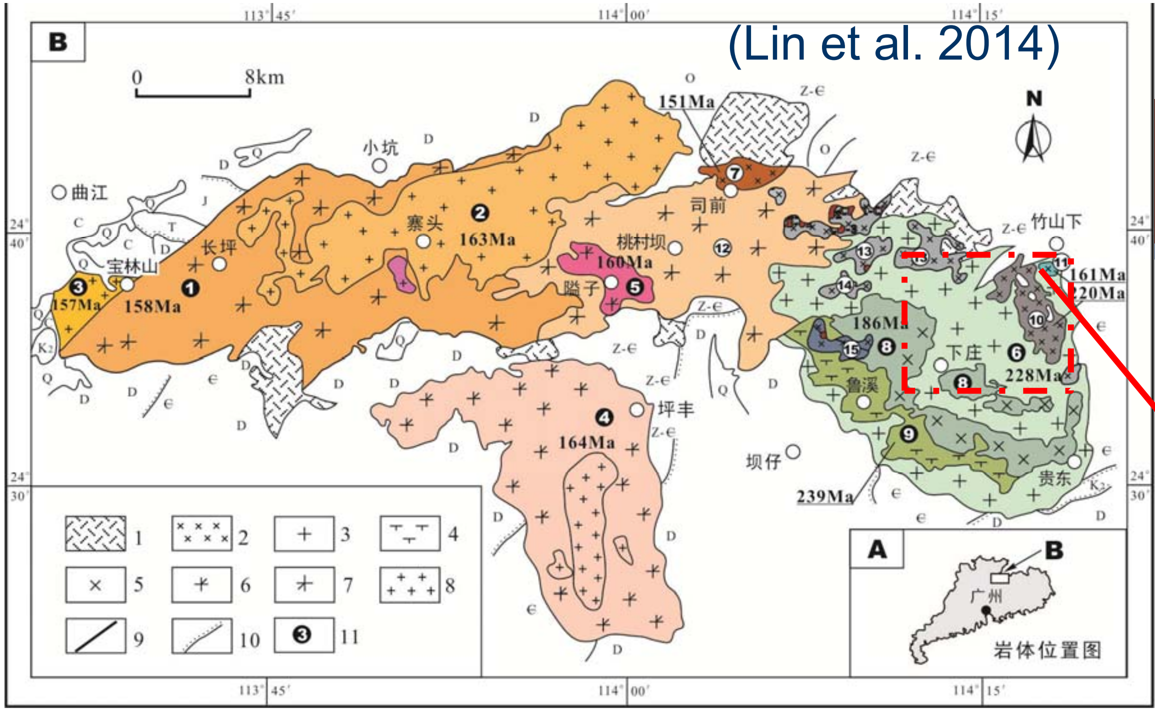
* middle to high temperature mineral assemblage and alterations
* disseminated/stockwork uranium ores in fissuration granite with extensive potassic alterations
* relatively older mineralization age with the superimposed reformation of late epithermal mineralization

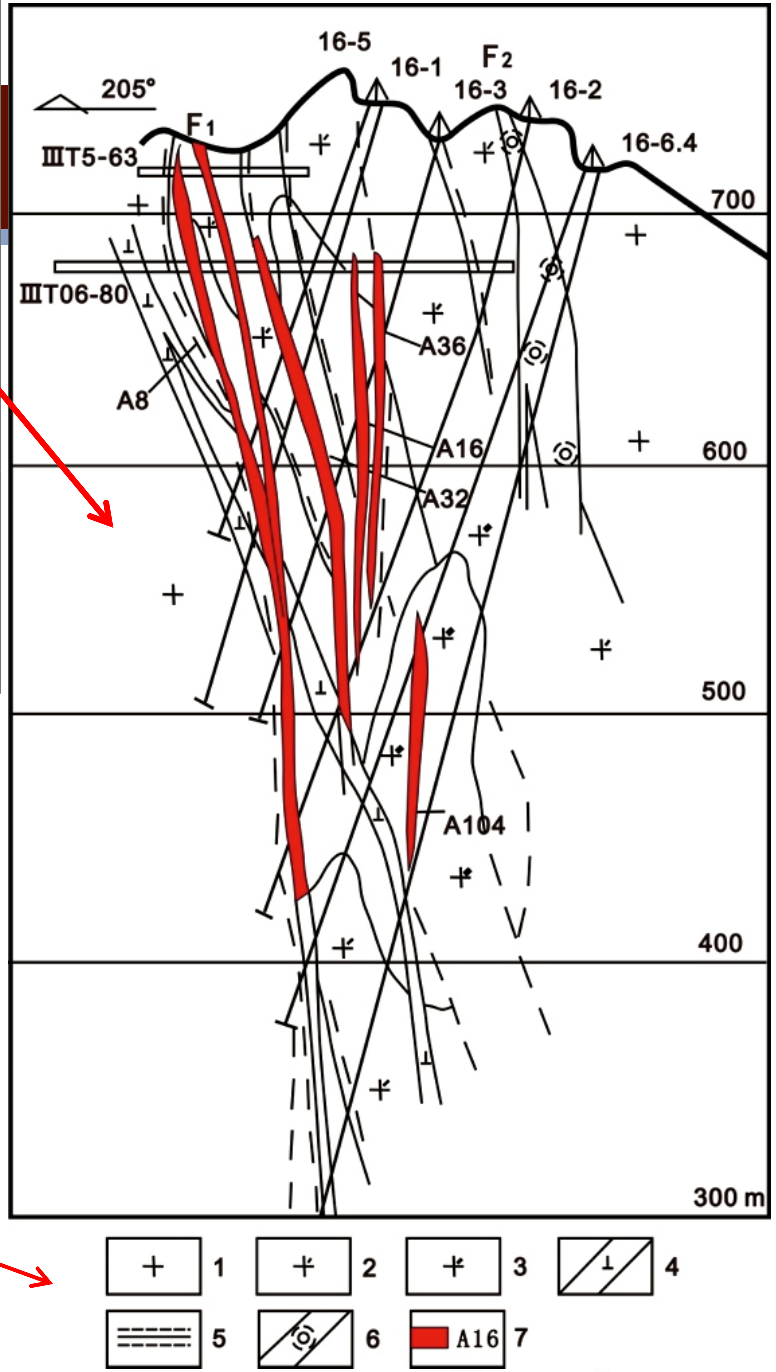
Recognized by researchers:

Hu et al. 2003, Tan et al. 2005, Du et al. 2006, 2009 etc.

Beresitization (pyritized phyllite) type

--- by Prof. Du in 2006, 2009

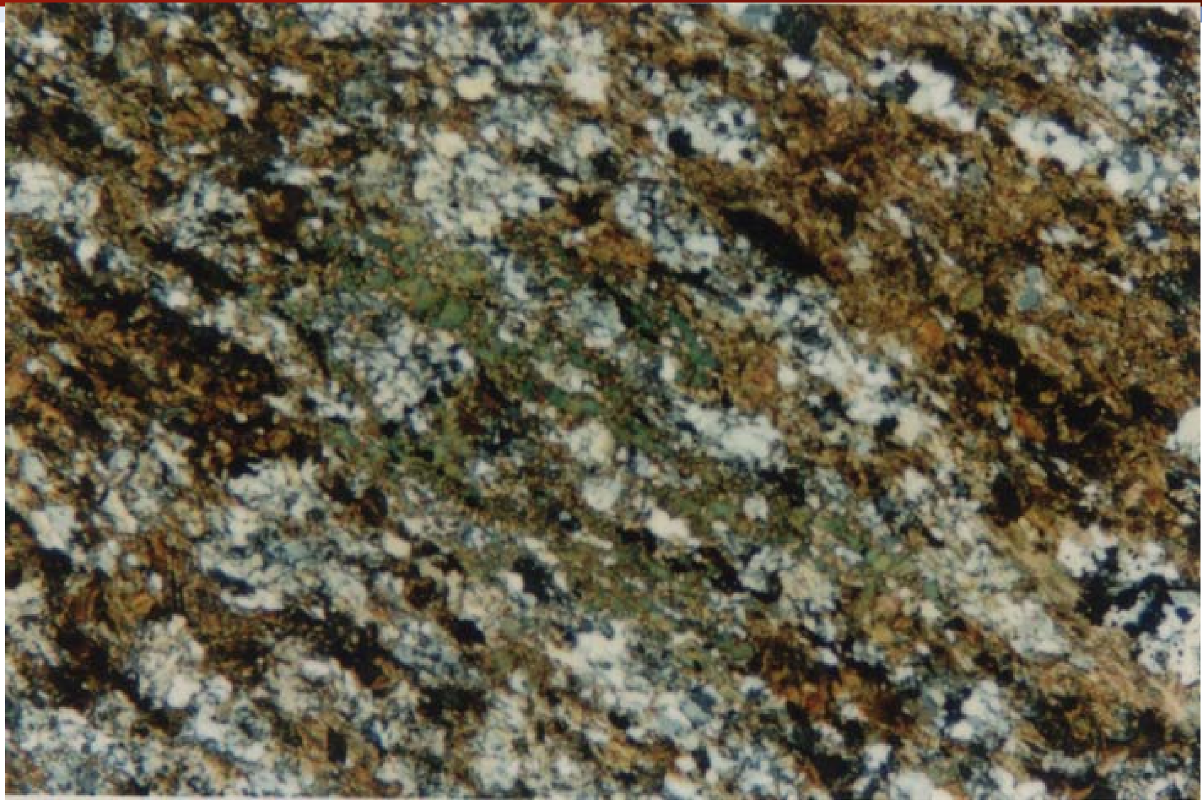




Example 1: Zhushanxia deposit in Xiazhuang U ore field

1, middle grain -porphyritic biotite granite;
2, fine grain muscovite granite;
3, potassic alteration granite
4, diabase
5, altered fissuration zone
6, silicification zone
7, ore body

Example 1: Zhushanxia deposit in Xiazhuang U ore field

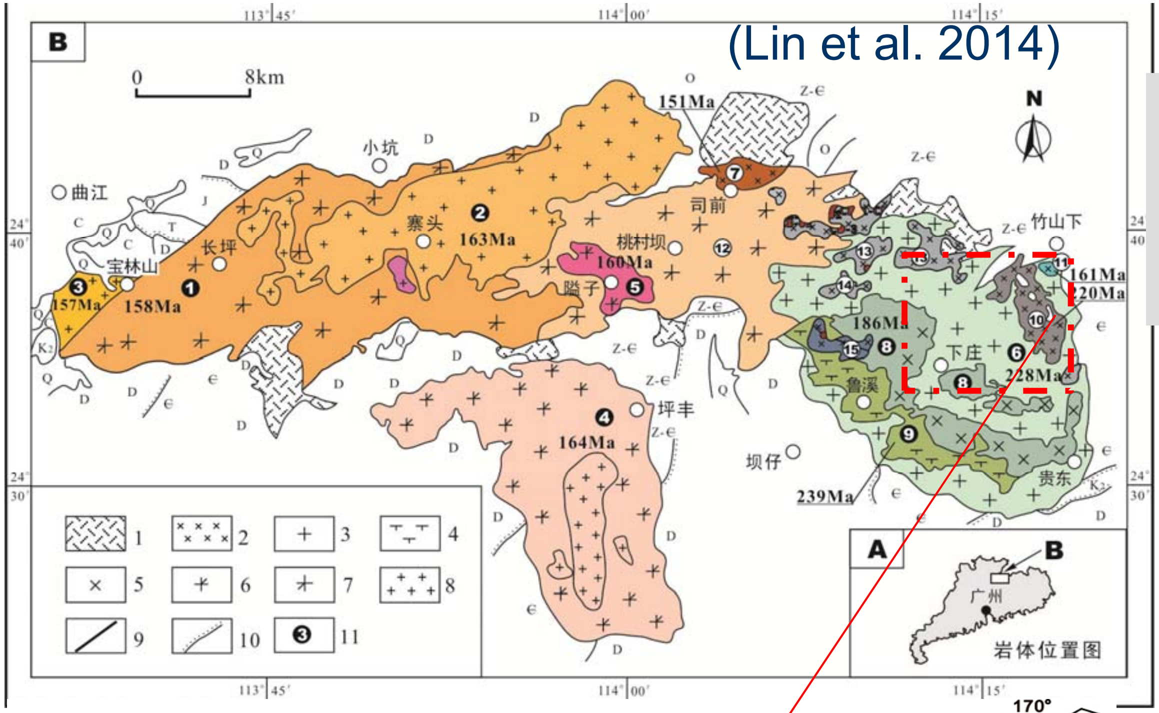


Thin section of ore
photo: (-) x25

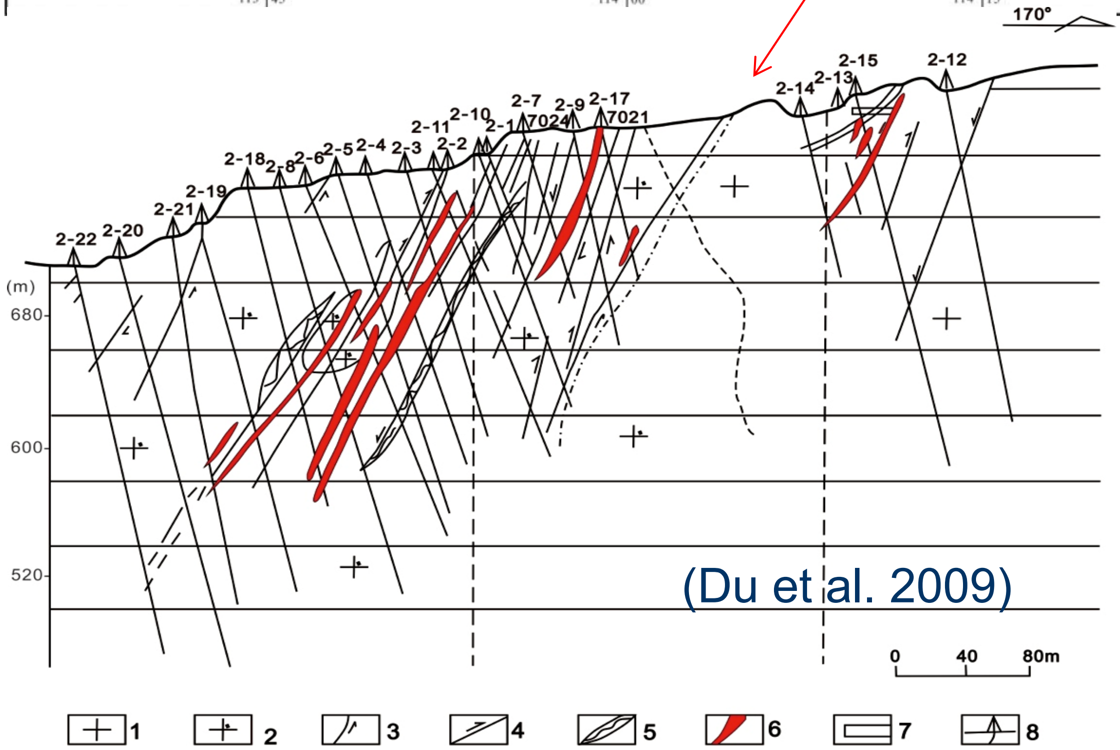
*** extensive potassic alteration with biotitization in ductile zone**

*** uraninite + scheelite, with tourmaline (U: 0.24-0.56％, W: 0.3%)**

*** age of uraninite: 146～165.5Ma (Hu et al, 2003)**



Example 2: Shituling deposit in Xiazhuang U ore field



1, middle grain -porphyritic biotite granite;
2, fine grain two-mica granite;
3, diabase
4, ductile fracture zone
5, fractured silicification zone
6, ore body
7, tunnel
8, drilling hole

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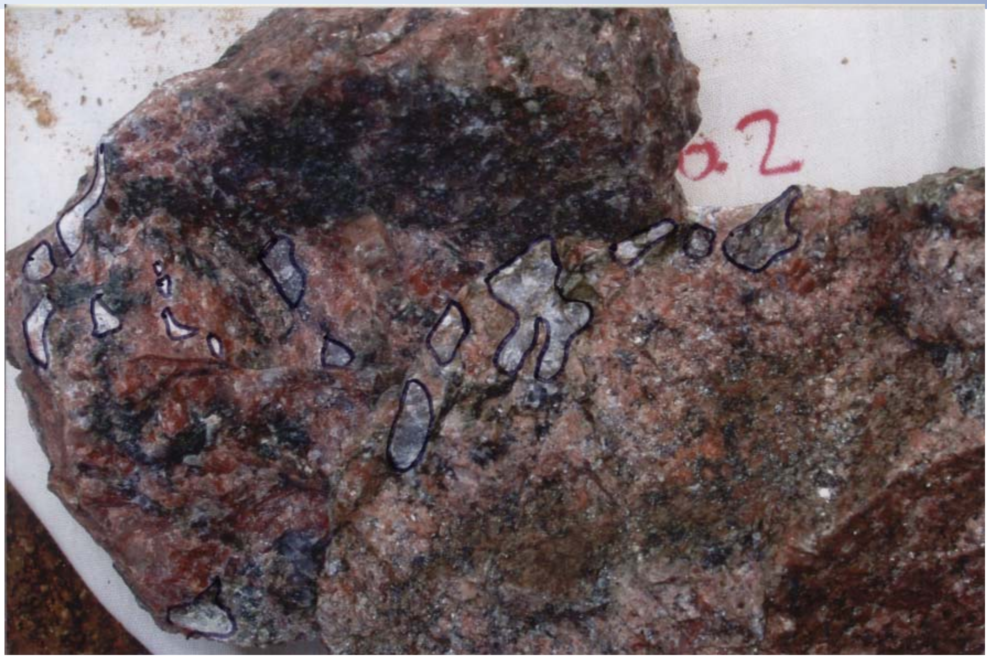
Example 2: Shituling Deposit in Xiazhuang U ore field



Micro-vein/disseminated Ore
(Du et al., 2006)

Age of host granite: 238 ± 2.3Ma

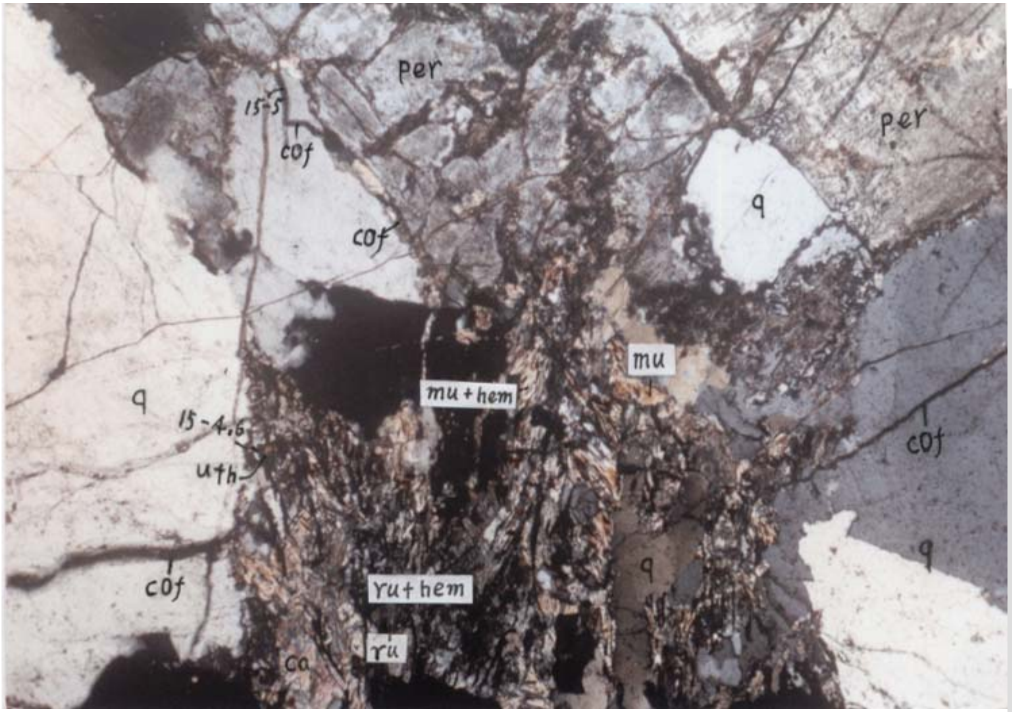
Age of U mineralization:
130－138Ma

Mineralization temperature:
290-338C

*** extensive potassic aleration, chloritization and sericitization in fissuration granite**

*** uraninite, coffinite and pichblende in black chlorite and sericite micro-veins**

(Du et al. 2006)

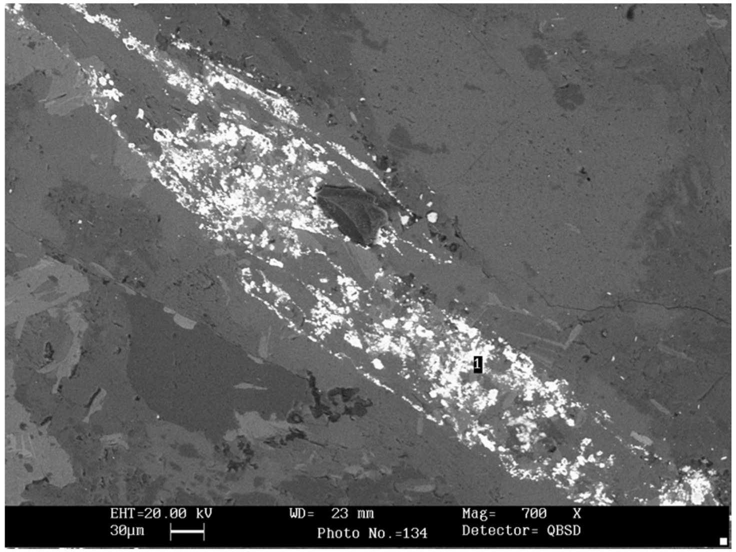


Thin section photo of fissuration granite (+) x 33

mu: hydromuscovite of biotite
ca: calcite， ru: rutile
hem: hematitte
uth: uranothorite (accessory mineral)
q: quartz， cof:: coffinite
per: perthitic microcline porphyroclast

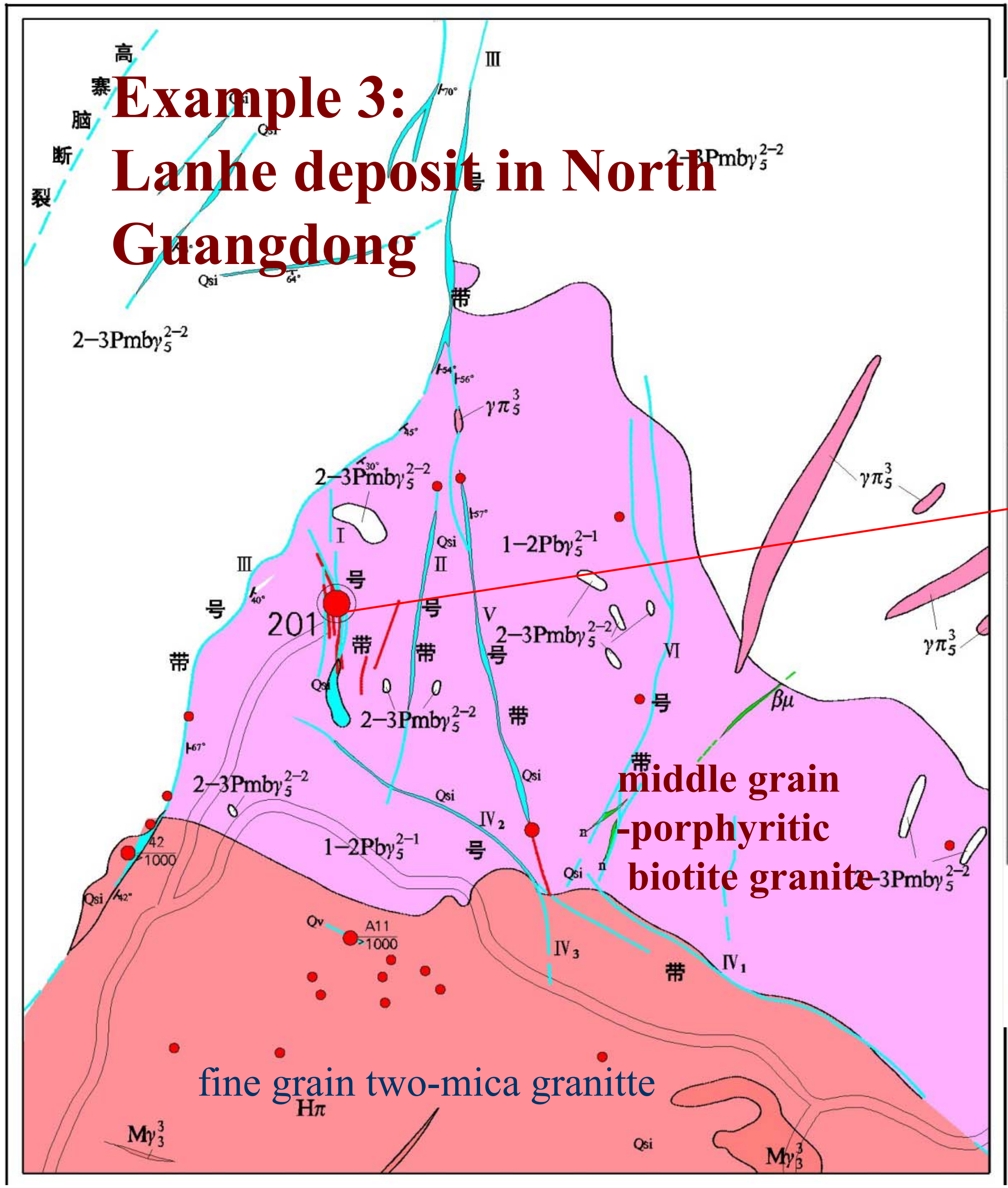
Original host rock:
biotite porphyritic monzogranite

Alpa track photo x 33



Fine grain uraninite aggregate in granite

Example 3: Lanhe deposit in North Guangdong



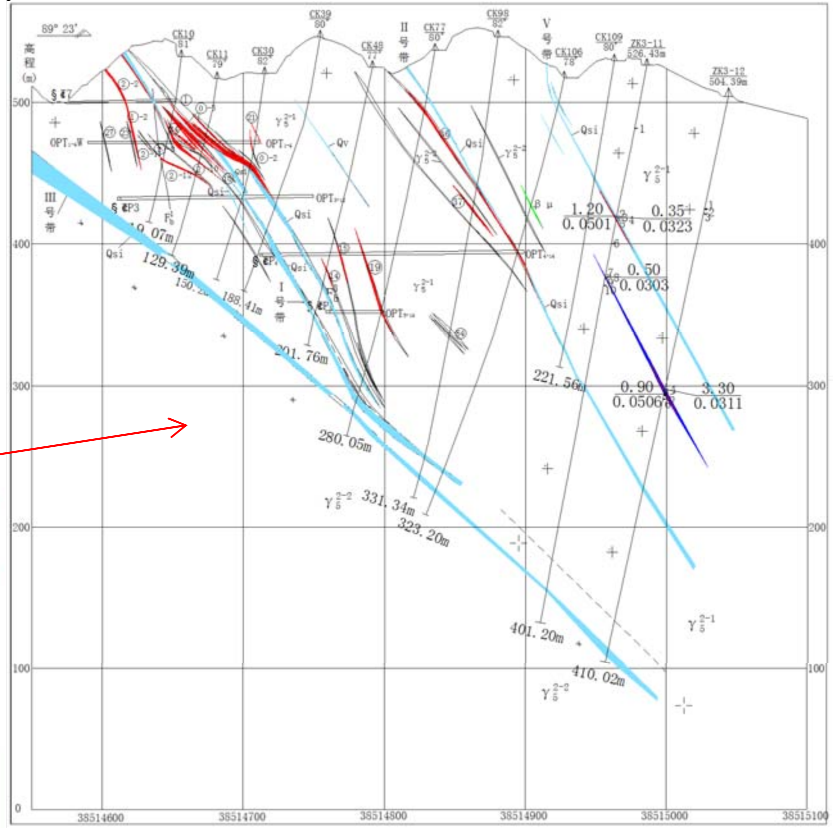


图11 澜河地区201矿床中心地段3号勘探线剖面图

* **Endogranitic**
* **Structure – control**

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Potassic alteration granite host rock

Pichblend micro-vein and Stockwork in fracture zone

4.3 General characteristics of hypothermal U mineralization

Type of ore: disseminated/stockwork in fissuration rocks

Alterations: alkaline metasomatism (potassic alteration), beresitization

Uranium minerals: uraninite, coffinite

Mineralization age: ＞ 100Ma

Mineralization T: ＞ 250 ℃

Gap(H/M): small, might related to small porphyry?

Mineralization mechanism:

boiling/mixing of fluids with ore forming solution derived from deep.

5. Discussion

More and more evidence indicates that there are multi-stages uranium mineralization in many granite-related uranium deposits in south China.

The early stage mineralization shares the characters of hypothermal U mineralization and had close relations to alkaline alterations.

* Evidence indicates the mixing of ore forming solution derived from deep (upper mantle?).

* Mineralization mechanism dominated by boiling and mixing of ore forming solution.

* Uranium mineralization priority occurred in the areas with lithospheric extension in crust thickening geological setting.

5. Discussion

- Contract term to “epithermal U mineralization ” , it’s not the typical intrusive high temperature mineralization.

* Detail studies needed, such as the mineralization ages, alterations and fluid inclusion for hypothermal mineralization.

* Relation of hypothermal mineralization to late epithermal uranium mineralization?

* *New target for future exploration?*

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