

# Fe-Cu-REE

# U-Pb

\*

## Re-Os

1 2

1\*\*

1

1

3

1

1 2

1 2

YE XianTao<sup>1 2</sup> ZHU WeiGuang<sup>1\*\*</sup> ZHONG Hong<sup>1</sup> HE DeFeng<sup>1</sup> REN Tao<sup>3</sup> BAI ZhongJie<sup>1</sup> FAN HongPeng<sup>1 2</sup> and HU WenJun<sup>1 2</sup>

1. 550002

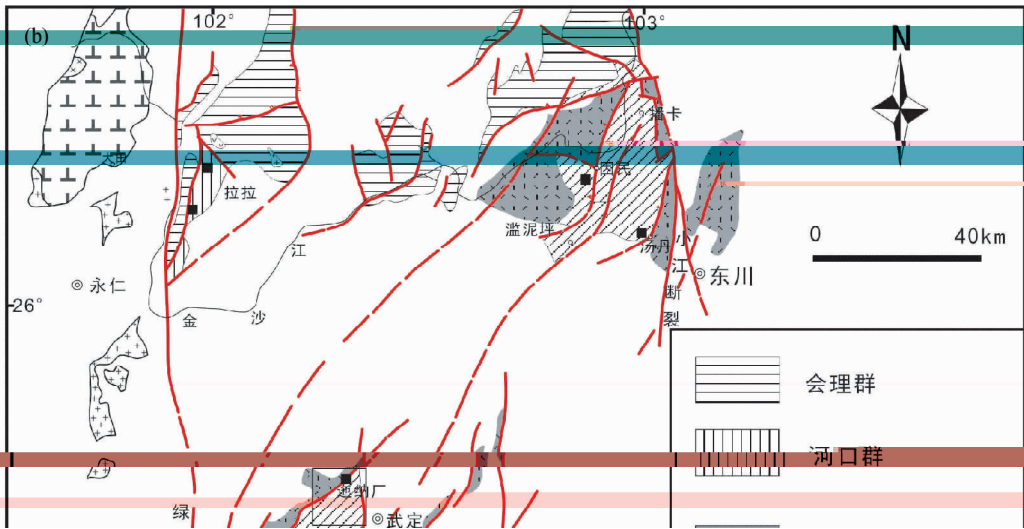
2. 100049

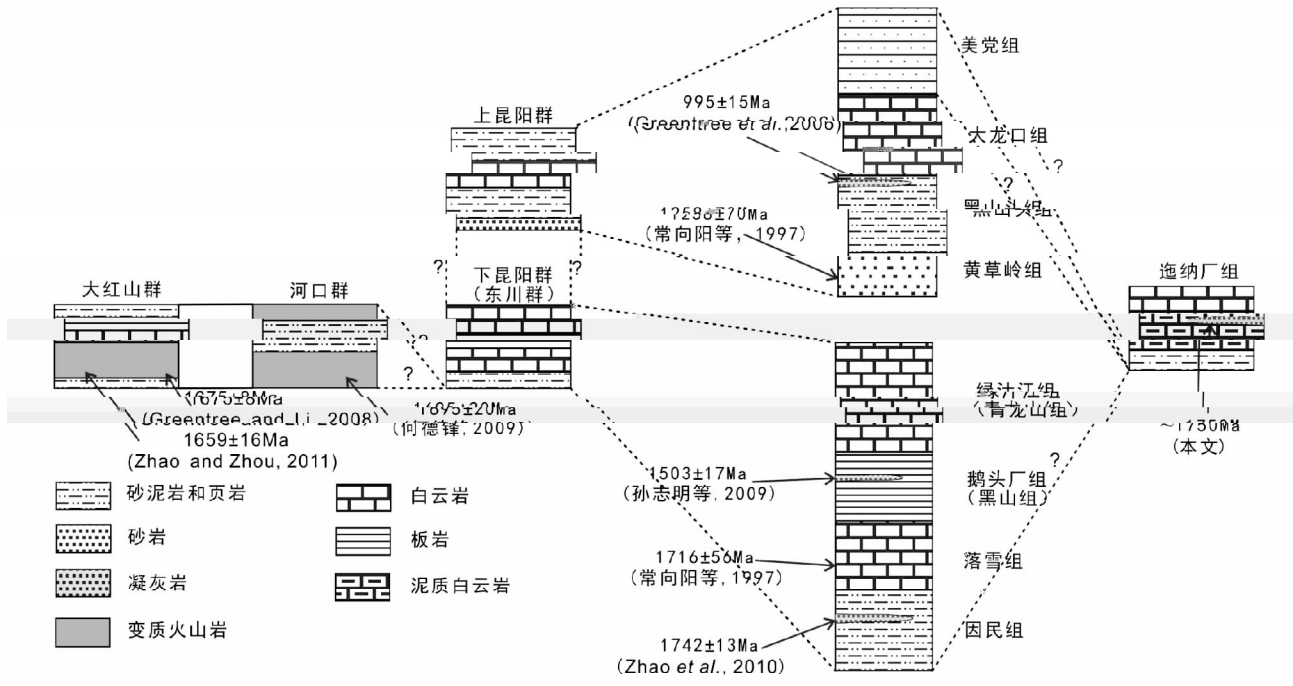
3. 650093

1. 550002 628017 0277600103D (000000

2. jE3 1 df 0 067.062803 0 0 7.762803 0 -6.598383 Tm 2.617711 57.655216 TD ( )5.9625 0 TD ( 61 )Tj 0 0 TD ( )Tj 0.500001 0 T







2 Zhao and Zhou 2011

Fig.2 Stratigraphic sequences of Kuniyang Group in the Kangdian region after Zhao and Zhou 2011

1032 ± 9Ma

2007

1.8 ~ 1.0Ga

400 ~ 700m

1000m 3.93 ~ 4.31m 200m

3

0.85% ~ 0.97%

41.93% ~ 44.53%

Fe-Cu-REE

2004

2004

1989

3

1cm

1mm

4a

5a b

5c d

70% 4c

5e

0.5 ~ 20cm

4b

5f

4d

8

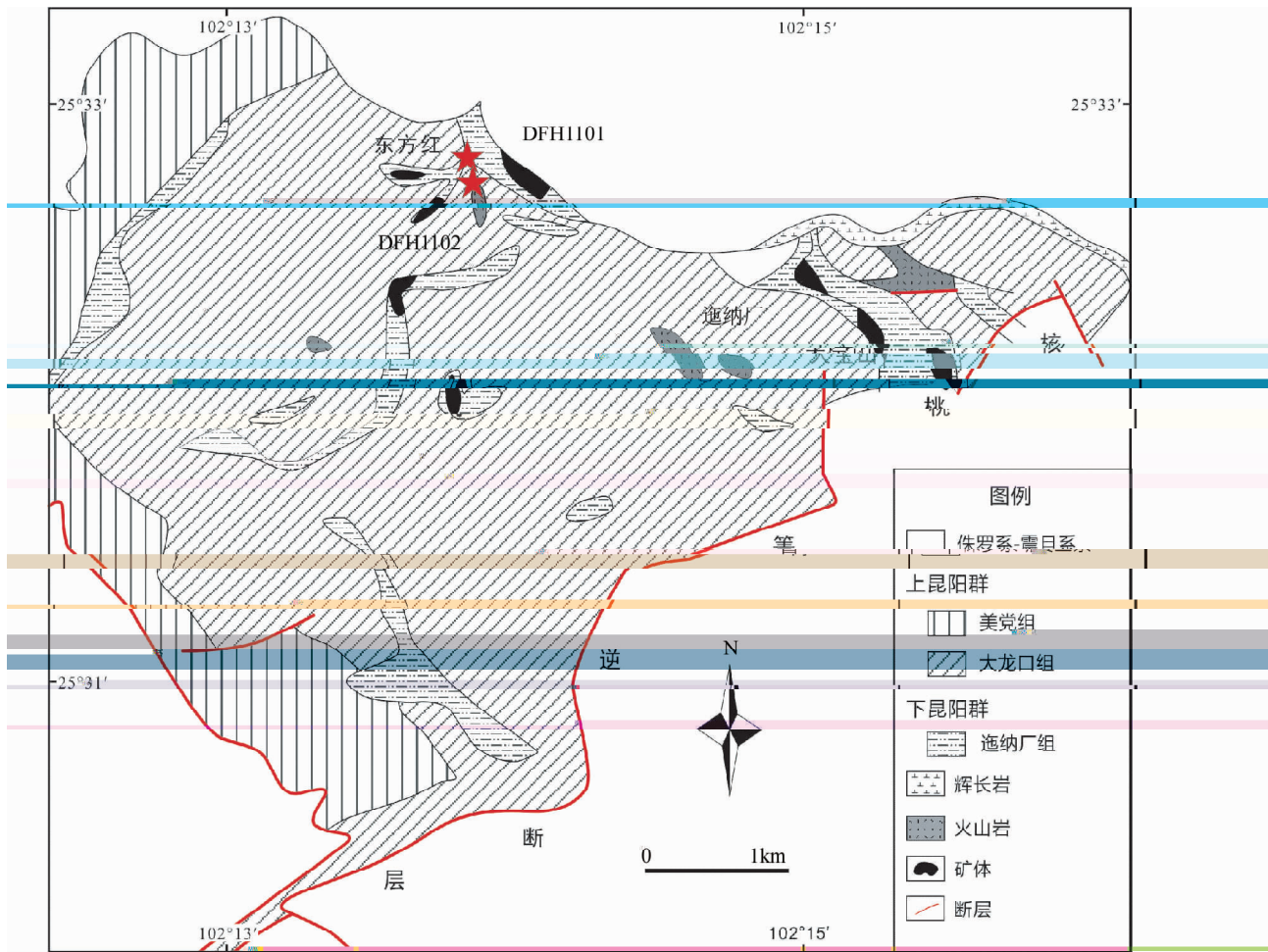
5g

3

5h

5

5i

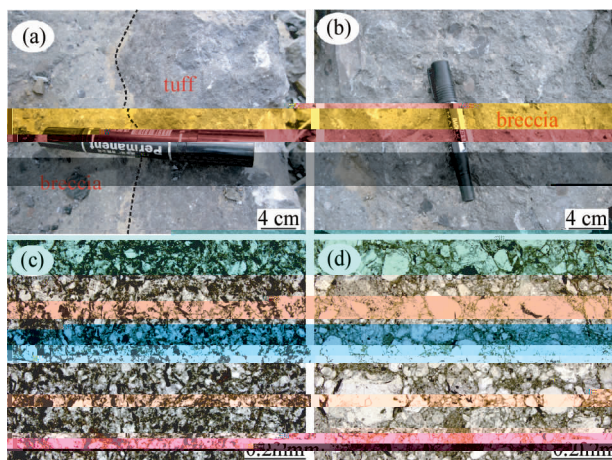


3

1990

Fig. 3 Simplified geological map of the Yinachang deposit in Wuding County Yunnan Province after Wu

1990



4

LA-ICP-MS U-Pb  
 DFH1101 N 25°32'53.1" E 102°13'34.3"  
 DFH1102 N 25°32'53.1" E 102°13'34.3"

CL

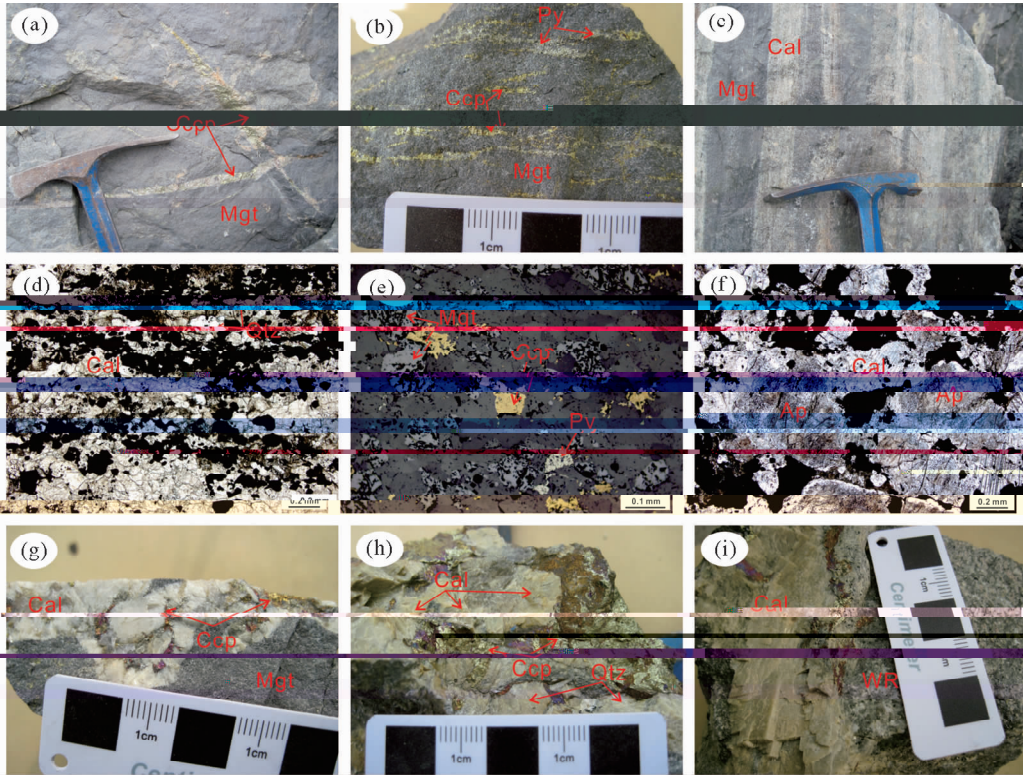
U-Pb

4

a - DFH1101 b - DFH1102  
 c - tuff- breccia-  
 d -

Fig. 4 Photographs and photomicrographs of the representative tuff a c and breccias b d from the Yinachang deposit



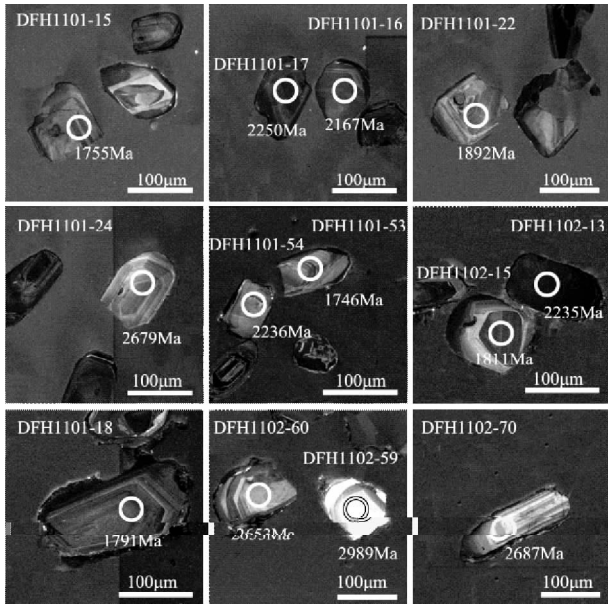


5

a b - c d - e - f - g - h -  
 i - . Cep- Cal- Py- Mgt- Ap- Qtz- WR-

Fig. 5 Photographs and photomicrographs of iron-copper ore from the Yinachang deposit

a b -vein-type ore c d -bedded ore e -disseminated ore f -apatite and calcite in the ore g -calcite in the magnetite ore h -calcite in the copper ore i -calcite in the wall-rock. Cep-chalcocopyrite Cal-calcite Py-pyrite Mgt-magnetite Ap-apatite Qtz-quartz WR-wall-rock



6

Fig. 6 Representative CL images of the detrital zircon grains for tuff and breccia from the Yinachang deposit

ICP-MS	91500
Plešovice	GJ-1
Si	NIST SRM 610
2011	Zr
Liu	Liu 2010a Hu
2010a b	ICPMSDataCal
200	40 ~ 60
ELAN DRC-e ICP-MS	99%
<sup>190</sup> Os	Re-Os
0.1g	Qi
200°C	2010
12h	<sup>185</sup> Re
Os Os 3mL	
2mol/L HCl	
AG 1-X8	Re Qi
3mL ICP-MS	2007 2010
	RSD% 3%



Continued Table 1

	$\times 10^{-6}$		Th/U		Ma													
	Pb	Th	U	$^{207}\text{Pb}/^{206}\text{Pb}$	$^{207}\text{Pb}/^{235}\text{U}$	$^{206}\text{Pb}/^{238}\text{U}$	$^{207}\text{Pb}/^{206}\text{Pb}$	$^{207}\text{Pb}/^{235}\text{U}$	$^{206}\text{Pb}/^{238}\text{U}$	$^{207}\text{Pb}/^{206}\text{Pb}$	$^{207}\text{Pb}/^{235}\text{U}$	$^{206}\text{Pb}/^{238}\text{U}$	$^{207}\text{Pb}/^{206}\text{Pb}$	$^{207}\text{Pb}/^{235}\text{U}$	$^{206}\text{Pb}/^{238}\text{U}$	$^{207}\text{Pb}/^{206}\text{Pb}$	$^{207}\text{Pb}/^{235}\text{U}$	$^{206}\text{Pb}/^{238}\text{U}$
				1 $\sigma$	1 $\sigma$	1 $\sigma$	1 $\sigma$	1 $\sigma$	1 $\sigma$	1 $\sigma$	1 $\sigma$	1 $\sigma$	1 $\sigma$	1 $\sigma$	1 $\sigma$	1 $\sigma$	1 $\sigma$	1 $\sigma$
-36	80.9	209	142	1.47	0.1200	0.0013	6.3927	0.0761	0.3834	0.0029	1967	19	2031	10	2092	14	97%	
-37	87.2	64.5	167	0.39	0.1413	0.0014	8.6286	0.0934	0.4396	0.0030	2243	18	2300	10	2349	13	97%	
-38	266.3	264	713	0.37	0.1105	0.0011	5.0255	0.0526	0.3267	0.0018	1809	19	1824	9	1822	9	99%	
-39	101.1	93.2	236	0.39	0.1188	0.0014	6.0271	0.0729	0.3643	0.0026	1939	21	1980	11	2002	12	98%	
-40	103.0	84.7	196	0.43	0.1444	0.0018	8.8538	0.1100	0.4396	0.0031	2280	21	2323	11	2349	14	98%	
-41	69.0	74.6	135	0.55	0.1341	0.0016	7.6710	0.0938	0.4103	0.0030	2154	20	2193	11	2216	13	98%	
-42	88.9	142	212	0.67	0.1095	0.0012	5.1544	0.0604	0.3375	0.0023	1792	20	1845	10	1875	11	98%	
-43	89.6	89.3	210	0.43	0.1452	0.0015	7.1268	0.0931	0.3524	0.0035	2300	17	2127	12	1946	17	91%	
-44	266.3	264	713	0.37	0.1103	0.0010	4.9246	0.0457	0.3202	0.0017	1806	16	1806	8	1791	8	99%	
-45	161.9	170	312	0.55	0.1391	0.0013	8.2752	0.0886	0.4270	0.0031	2217	16	2262	10	2292	14	98%	
-46	129.0	253	289	0.87	0.1203	0.0012	5.6090	0.0600	0.3350	0.0022	1961	23	1917	9	1863	10	97%	
-47	211.5	374	438	0.85	0.1389	0.0014	7.5703	0.0909	0.3905	0.0031	2213	18	2181	11	2125	14	97%	
-48	109.7	155	230	0.67	0.1260	0.0013	6.6323	0.0745	0.3783	0.0027	2044	18	2064	10	2068	12	99%	
-49	173.7	177	327	0.54	0.1434	0.0013	8.7362	0.0925	0.4378	0.0031	2269	15	2311	10	2341	14	98%	
-50	137.0	125	343	0.36	0.1169	0.0011	5.4973	0.0531	0.3382	0.0019	1910	18	1900	8	1878	9	98%	
-51	215.8	177	347	0.51	0.1799	0.0016	12.2556	0.1307	0.4904	0.0041	2654	14	2624	10	2573	18	98%	
-52	98.4	41.0	157	0.26	0.1785	0.0017	12.9855	0.1377	0.5232	0.0036	2639	11	2679	10	2713	15	98%	
-53	48.7	68.7	120	0.57	0.1068	0.0013	4.8869	0.0608	0.3302	0.0027	1746	22	1800	10	1839	13	97%	
-54	106.4	109	195	0.56	0.1406	0.0015	8.4237	0.0995	0.4313	0.0031	2236	19	2278	11	2312	14	98%	
-55	134.8	120	308	0.39	0.1266	0.0013	6.5019	0.0767	0.3693	0.0027	2052	19	2046	10	2026	13	99%	
-56	73.4	196	140	1.40	0.1222	0.0014	5.9134	0.0683	0.3483	0.0022	1989	20	1963	10	1926	10	98%	
-57	62.0	70.0	119	0.59	0.1379	0.0014	7.9104	0.0866	0.4133	0.0028	2211	17	2221	10	2230	13	99%	
-58	36.1	69.7	74.7	0.93	0.1208	0.0016	6.0204	0.0861	0.3598	0.0031	1969	23	1979	12	1981	15	99%	
-59	82.1	263	167	1.58	0.1116	0.0013	5.0164	0.0616	0.3236	0.0023	1828	21	1822	10	1807	11	99%	
-60	187.0	197	354	0.56	0.1432	0.0015	8.3718	0.0911	0.4207	0.0027	2266	18	2272	10	2264	12	99%	
-61	49.4	77.2	82.9	0.93	0.1454	0.0019	8.8411	0.1230	0.4378	0.0035	2294	23	2322	13	2341	16	99%	
-62	123.4	92.1	250	0.37	0.1429	0.0015	8.1120	0.0905	0.4081	0.0025	2263	19	2244	10	2206	12	98%	
-63	215.1	194	431	0.45	0.1451	0.0014	8.2793	0.0852	0.4102	0.0023	2289	17	2262	9	2216	10	97%	
-64	133.9	124	299	0.42	0.1377	0.0014	7.0855	0.0792	0.3696	0.0026	2198	18	2122	10	2028	12	95%	
-65	160.0	132	332	0.40	0.1434	0.0014	7.9348	0.0791	0.3978	0.0024	2269	17	2224	9	2159	11	97%	
-66	79.1	70.6	174	0.41	0.1253	0.0014	6.7131	0.0808	0.3852	0.0028	2035	20	2074	11	2101	13	98%	
-67	62.0	61.8	109	0.57	0.1456	0.0017	9.2008	0.1131	0.4555	0.0035	2295	20	2358	11	2420	16	97%	
-68	63.2	77.5	159	0.49	0.1106	0.0014	5.2508	0.0704	0.3418	0.0027	1810	23	1861	11	1895	13	98%	
-69	123.9	94.3	238	0.40	0.1459	0.0017	8.7938	0.1075	0.4335	0.0030	2298	19	2317	11	2321	13	99%	
-70	151.1	340	302	1.13	0.1213	0.0013	6.1160	0.0688	0.3626	0.0024	1976	14	1993	10	1994	11	99%	
-71	63.0	75.0	117	0.64	0.1443	0.0016	8.6918	0.0966	0.4329	0.0027	2279	19	2306	10	2319	12	99%	



Continued Table 1

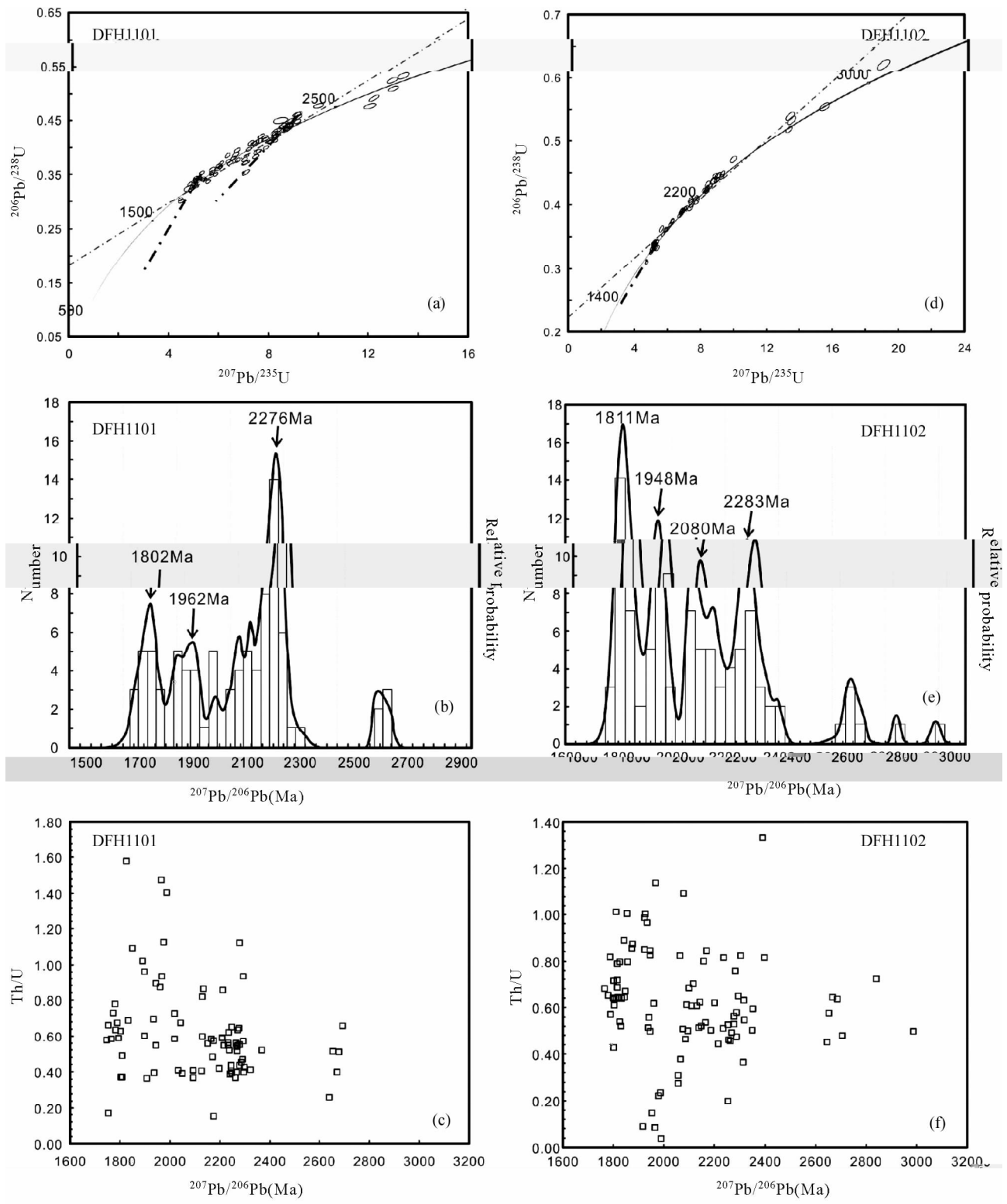
	$\times 10^{-6}$		Th/U	Ma											
	Pb	Th		$^{207}\text{Pb}/^{206}\text{Pb}$	$^{207}\text{Pb}/^{235}\text{U}$	$^{207}\text{Pb}/^{206}\text{Pb}$	$^{207}\text{Pb}/^{235}\text{U}$								
-72	136.9	136	0.66	0.0018	13.0323	0.1292	0.5076	0.0030	2694	16	2682	9	2646	13	98%
-73	122.1	150	0.65	0.0014	8.3021	0.0890	0.4200	0.0027	2250	50	2265	10	2260	12	99%
-74	144.7	227	0.86	0.0013	7.7595	0.0846	0.4192	0.0030	2135	18	2204	10	2257	13	97%
-75	156.1	143	0.41	0.0013	6.7816	0.0713	0.3749	0.0023	2094	23	2083	9	2052	11	98%
-76	118.4	169	0.58	0.0013	5.0668	0.0618	0.3367	0.0025	1766	21	1831	10	1871	12	97%
-77	88.2	103	0.62	0.0015	8.5921	0.1031	0.4386	0.0035	2237	19	2296	11	2344	16	97%
-78	123.2	151	0.55	0.0012	6.1333	0.0680	0.3691	0.0027	1946	18	1995	10	2025	13	98%
-79	64.8	96.5	0.72	0.0013	6.7847	0.0806	0.3925	0.0030	2020	-14	2084	11	2134	14	97%
-80	63.0	109	0.73	0.0012	5.1333	0.0626	0.3408	0.0026	1773	20	1842	10	1890	12	97%
-81	143.8	111	0.37	0.0012	7.3295	0.0815	0.4065	0.0031	2094	17	2152	10	2199	14	97%
-82	64.1	65.3	0.55	0.0016	8.8574	0.1082	0.4419	0.0035	2280	20	2323	11	2359	16	98%
-83	133.1	168	0.59	0.0014	7.1239	0.0875	0.3709	0.0030	2211	17	2127	11	2034	14	95%
-84	79.6	109	0.60	0.0014	5.7745	0.0709	0.3580	0.0025	1898	22	1943	11	1973	12	98%
DFH1102															
-01	87.6	164	0.82	0.0012	4.9917	0.0618	0.3287	0.0025	1787	22	1818	10	1832	12	99%
-02	24.28	34.6	0.61	0.0016	5.2812	0.0836	0.3466	0.0035	1806	21	1866	14	1918	17	97%
-03	36.8	62	0.68	0.0016	4.8210	0.0728	0.3235	0.0029	1767	27	1789	13	1807	14	98%
-04	213.4	230	0.49	0.0012	7.1364	0.0634	0.3575	0.0017	2270	15	2129	8	1971	8	92%
-05	113.9	114	0.52	0.0012	7.5570	0.0714	0.4069	0.0024	2148	17	2180	8	2201	11	99%
-06	62.8	91.4	0.82	0.0016	8.9171	0.1226	0.4145	0.0041	2399	18	2330	13	2235	19	95%
-07	53.3	122	1.01	0.0013	4.8264	0.0546	0.3159	0.0018	1811	16	1790	10	1770	9	98%
-08	74.5	104	0.68	0.0015	6.7038	0.0784	0.3709	0.0025	2102	20	2073	10	2034	12	98%
-09	123.5	154	0.62	0.0014	6.9575	0.0832	0.3754	0.0031	2143	19	2106	11	2055	14	97%
-10	252.0	284	0.63	0.0018	8.1843	0.0999	0.3968	0.0026	2317	21	2252	11	2154	12	95%
-11	95.2	86.7	0.64	0.0017	13.2204	0.1292	0.5231	0.0032	2668	15	2696	9	2712	14	99%
-12	200.3	67.7	0.15	0.0012	6.0441	0.0620	0.3623	0.0020	1954	13	1982	9	1993	9	99%
-13	114.0	107	0.51	0.0013	8.3927	0.0873	0.4291	0.0030	2235	16	2274	9	2302	13	98%
-14	85.6	91.3	0.50	0.0021	6.0186	0.0983	0.3624	0.0029	1946	38	1979	14	1994	14	99%
-15	49.0	76.3	0.64	0.0014	5.0646	0.0700	0.3313	0.0029	1811	18	1830	12	1845	14	99%
-16	75.7	131	0.84	0.0014	5.9654	0.0721	0.3601	0.0025	1946	21	1971	11	1983	12	99%
-17	33.53	22.3	0.45	0.0022	13.4050	0.1688	0.5381	0.0045	2647	53	2709	12	2775	19	97%
-18	49.4	68.7	0.57	0.0012	4.9766	0.0554	0.3283	0.0023	1791	20	1815	9	1830	11	99%
-19	61.6	61.1	0.50	0.0013	7.6532	0.0773	0.4029	0.0026	2187	17	2191	9	2182	12	99%
-20	79.6	92.6	0.51	0.0012	5.8956	0.0590	0.3577	0.0022	1939	23	1961	9	1971	10	99%
-21	49.6	82.1	0.82	0.0013	6.7275	0.0734	0.3794	0.0026	2065	13	2076	10	2073	12	99%
-22	63.0	62.8	0.53	0.0015	8.5432	0.0972	0.4267	0.0029	2280	19	2291	10	2291	13	99%



Continued Table 1

	$\times 10^{-6}$		Th/U	Ma				$1\sigma$	$1\sigma$	$1\sigma$	$1\sigma$	$1\sigma$				
	Pb	Th		U	$^{207}\text{Pb}/^{206}\text{Pb}$	$^{206}\text{Pb}/^{238}\text{U}$	$^{207}\text{Pb}/^{206}\text{Pb}$						$^{207}\text{Pb}/^{235}\text{U}$	$^{206}\text{Pb}/^{238}\text{U}$		
	$1\sigma$	$1\sigma$		$1\sigma$	$1\sigma$	$1\sigma$	$1\sigma$						$1\sigma$	$1\sigma$		
-59	31.92	19.8	40.0	0.50	0.0026	18.8909	0.2486	0.6217	0.0055	2989	19	3036	13	3117	22	97%
-60	55.9	47.1	82.0	0.57	0.0020	13.4778	0.1675	0.5401	0.0042	2653	18	2714	12	2784	17	97%
-61	26.04	43.5	61.0	0.71	0.0101	5.1550	0.0768	0.3391	0.0027	1802	26	1845	13	1882	13	98%
-62	112.5	59.0	266	0.22	0.0127	6.3109	0.0740	0.3741	0.0024	1981	53	2020	10	2048	11	98%
-63	47.2	55.3	85.2	0.65	0.01457	8.8067	0.1194	0.4369	0.0033	2295	22	2318	12	2337	15	99%
-64	76.7	119	185	0.64	0.0100	5.1465	0.0640	0.3371	0.0025	1799	16	1844	11	1873	12	98%
-65	44.3	70.9	106	0.67	0.0114	5.2148	0.0658	0.3337	0.0023	1847	23	1855	11	1856	11	99%
-66	29.14	52.5	65.9	0.80	0.0116	5.2541	0.0746	0.3412	0.0024	1825	26	1861	12	1892	12	98%
-67	63.2	128	130	0.99	0.01179	5.8883	0.0706	0.3604	0.0025	1925	20	1960	10	1984	12	98%
-68	51.6	65.7	126	0.52	0.01120	5.2242	0.0701	0.3365	0.0025	1832	23	1857	11	1870	12	99%
-69	86.1	82.9	115	0.72	0.0024	15.5602	0.1927	0.5550	0.0039	2842	14	2850	12	2846	16	99%
-70	46.0	42.0	66.2	0.64	0.0136	13.5549	0.1696	0.5334	0.0044	2687	20	2719	12	2756	19	98%
-71	59.9	85.4	105	0.81	0.01408	8.4530	0.1001	0.4327	0.0031	2237	20	2281	11	2318	14	98%
-72	54.9	92.8	130	0.72	0.01110	5.1143	0.0623	0.3320	0.0023	1817	21	1838	10	1848	11	99%
-73	19.44	20.6	35.7	0.58	0.01450	8.8198	0.1403	0.4382	0.0042	2289	24	2320	15	2343	19	99%
-74	43.9	62.1	96.8	0.64	0.01129	5.6604	0.0775	0.3616	0.0032	1847	18	1925	12	1990	15	96%
-75	52.0	69.6	99.6	0.70	0.01313	7.4376	0.0966	0.4073	0.0032	2117	21	2166	12	2202	15	98%
-76	51.9	81.3	128	0.64	0.01115	5.0472	0.0683	0.3250	0.0023	1833	18	1827	11	1814	11	99%
-77	135.6	54.7	276	0.20	0.01420	8.3715	0.0974	0.4228	0.0028	2254	20	2272	11	2273	13	99%
-78	48.6	53.1	99.1	0.54	0.01351	7.4327	0.1073	0.3946	0.0031	2165	23	2165	13	2144	14	99%
-79	79.1	93.5	154	0.61	0.01324	7.4413	0.0910	0.4038	0.0029	2131	20	2166	11	2187	13	99%
-80	105.5	131	236	0.56	0.01191	5.9883	0.0654	0.3611	0.0024	1943	19	1974	10	1987	11	99%
-81	173.4	174	320	0.54	0.01476	9.0175	0.0919	0.4386	0.0028	2318	21	2340	9	2344	12	99%
-82	150.7	227	284	0.80	0.01346	7.4881	0.0761	0.3989	0.0024	2159	17	2172	9	2164	11	99%
-83	160.0	213	347	0.62	0.01203	6.0871	0.0616	0.3630	0.0020	1961	23	1988	9	1996	10	99%
-84	54.2	84.6	132	0.64	0.01113	5.0491	0.0645	0.3255	0.0022	1820	22	1828	11	1816	11	99%
-85	30.4	56.5	70.9	0.80	0.01136	5.3533	0.0895	0.3403	0.0033	1858	29	1877	14	1888	16	99%
-86	111.2	68.5	250	0.27	0.01270	6.7727	0.0780	0.3827	0.0025	2057	18	2082	10	2089	12	99%
-87	80.5	84.9	143	0.59	0.01507	9.3012	0.1041	0.4435	0.0029	2353	19	2368	10	2366	13	99%
-88	44.90	36.6	97.4	0.38	0.01276	6.9153	0.0855	0.3895	0.0028	2066	16	2101	11	2121	13	99%
-89	86.3	134	159	0.84	0.01355	7.7422	0.0859	0.4104	0.0029	2170	17	2202	10	2217	13	99%
-90	149.3	102	331	0.31	0.01271	6.8407	0.0719	0.3864	0.0023	2058	18	2091	9	2106	11	99%
-91	58.7	53.0	112	0.47	0.01448	8.6416	0.1050	0.4291	0.0031	2287	19	2301	11	2302	14	99%
-92	39.6	60.6	95.7	0.63	0.01103	5.1442	0.0720	0.3354	0.0024	1806	24	1843	12	1865	12	98%
-93	61.9	62.3	119	0.53	0.01415	8.3089	0.1079	0.4230	0.0029	2256	50	2265	12	2274	13	99%

Pb



7 U-Pb  $^{207}\text{Pb}/^{206}\text{Pb}$  Th/U- $^{207}\text{Pb}/^{206}\text{Pb}$   
 Fig. 7 Plot of U-Pb concordant curve  $^{207}\text{Pb}/^{206}\text{Pb}$  age frequency and Th/U- $^{207}\text{Pb}/^{206}\text{Pb}$  age diagram of the det d d d

Table 2 Re-Os isotope compositions for chalcopyrite from the Yinachang deposit

	<sup>187</sup> Re × 10 <sup>-9</sup>	1σ	<sup>187</sup> Os × 10 <sup>-9</sup>	1σ	Re × 10 <sup>-9</sup>	1σ	Os × 10 <sup>-9</sup>	1σ	Ma	1σ
YNC1006	562.306	16.269	16.881	0.314	898.253	25.989	0.023	0.006	1732	23
10YNC-40	161.659	2.145	4.455	0.061	258.242	3.426	0.017	0.001	1638	22
YNC1010	4.615	0.108	0.118	0.003	7.373	0.172	0.003	0.000	1719	20
10YNC-32	12.859	0.300	0.366	0.004	20.541	0.480	0.004	0.000	1690	20
10YNC-41	246.010	30.390	6.836	0.079	392.988	48.547	0.005	0.001	1651	19
YNC1112	4.388	0.149	0.073	0.005	7.010	0.239	0.002	0.000	1687	19

5

5.1 U-Pb

LA-ICP-MS U-Pb

1 6 #00‡ CL

7 U-Pb <sup>207</sup>Pb/  
<sup>206</sup>Pb Th/U-<sup>207</sup>Pb/<sup>206</sup>Pb

DFH1101 2000

84 95%  
<sup>207</sup>Pb/<sup>206</sup>Pb 1746 ± 22Ma <sup>207</sup>Pb/<sup>206</sup>Pb  
2694 ± 16Ma 5 2500Ma  
1.75 ~ 1.85Ga

1.90 ~ 2.00Ga 2.20 ~ 2.35Ga  
<sup>207</sup>Pb/<sup>206</sup>Pb 1796 ± 15Ma n  
= 16 MSWD = 1.5 2262 ± 12Ma n = 34 MSWD = 3.5  
1800Ma 1960Ma 2270Ma

7b CL  
6 Th/U 0.1

0.4 ~ 1.0 7c  
DFH1102 2500

93  
95% <sup>207</sup>Pb/<sup>206</sup>Pb 19Ma  
2500Ma

566.1 88Ga 11.148 TD ( 1/4) 2000 2.408 24505 0 TD (020 1.01 0 TD 1979 0 TD ( A

1796 ±  
1800M 208

7e C

6 Th/U  
~ 1.0 7f

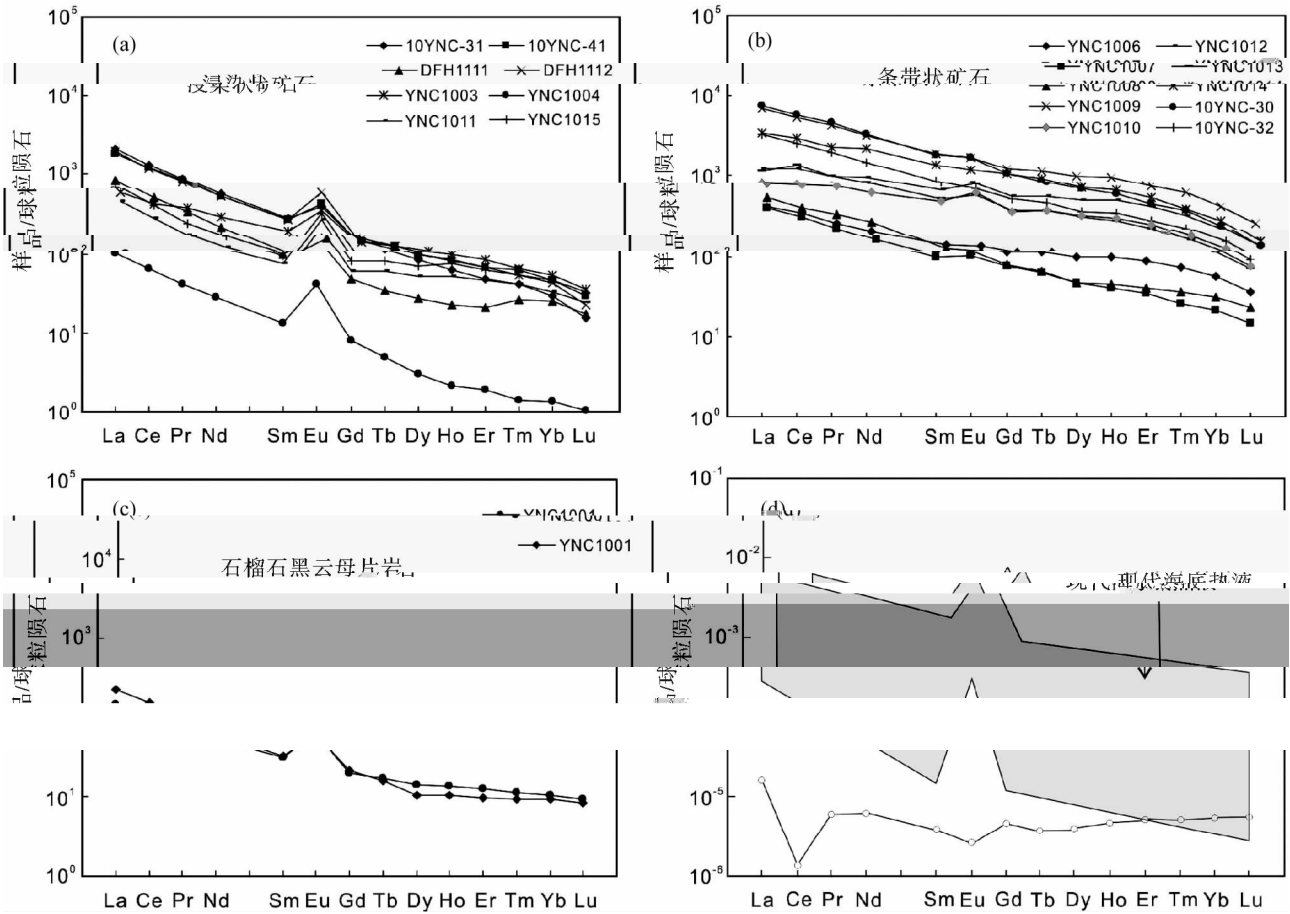
i











9 a b c  
 d Craddock 2010 Elderfield and Greaves 1982  
 Boynton 1984  
 Fig. 9 Chondrite-normalized REE patterns for disseminated ores a banded ores b and garnet biotite schist c of the Yinachang deposit  
 REE patterns for submarine hydrothermal fluids after Craddock 2010 REE pattern for seawater after Elderfield and Greaves 1982 chondrite-normalizing values after Boynton 1984

IOCG

7

1.7Ga

1 LA-ICP-MS U-Pb

1750Ma

1.7Ga Columbia Rogers and Santosh 2002

2 Fe-Cu-REE Re-Os 1690 ± 99Ma 1.7Ga

Zhao 2002

3

Columbia 2011 Wang 2012 Yu 2012 1.7Ga Zhao and Zhou

Fe-Cu

U-Pb

Re-Os

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