minerals

Article

Iron Isotope Constraints on the Mineralization Process of Shazi Sc-rich Laterite Deposit in Qilong County, China

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1. Mineralogical composition

Crystal phase identification for representative bulk sample was performed at the Institute of Geochemistry, Chinese Academy of Sciences using X-ray diffraction (XRD) with a diffractometer (model: D/Max2200, Japan) that used nickel-filtered Cu Kα radiation (λ = 1.54178 Å). The working voltage and current were 40 kV and 30 mA, respectively. The patterns were recorded in the 2θ range of 6 to 50 °, using the step-scanning mode with 0.04° step size and a counting time of 5 s per step. The crystalline phases in the resulting sample were determined by comparing their XRD patterns with the standard patterns of various crystalline phases that were could possibly form in the sample under the given conditions.

According to XRD (Appendix), fresh basalt is mainly composed of clinopyroxene and plagioclase, and iron oxides include magnetite. In addition to clinopyroxene, plagioclase and magnetite, montmorillonite appears in weathered basalt, while laterite is mainly composed of clay minerals and iron (oxyhydr)oxides (such as geothite and hematite). Magnetite appears in heavy sand minerals. Based on the existing evidence, magnetite in basalt is obviously different from the other Fe-bearing minerals in isotopic composition, magnetite is the only mineral existing in all three lithologies, and the isotope of magnetite has changed significantly.

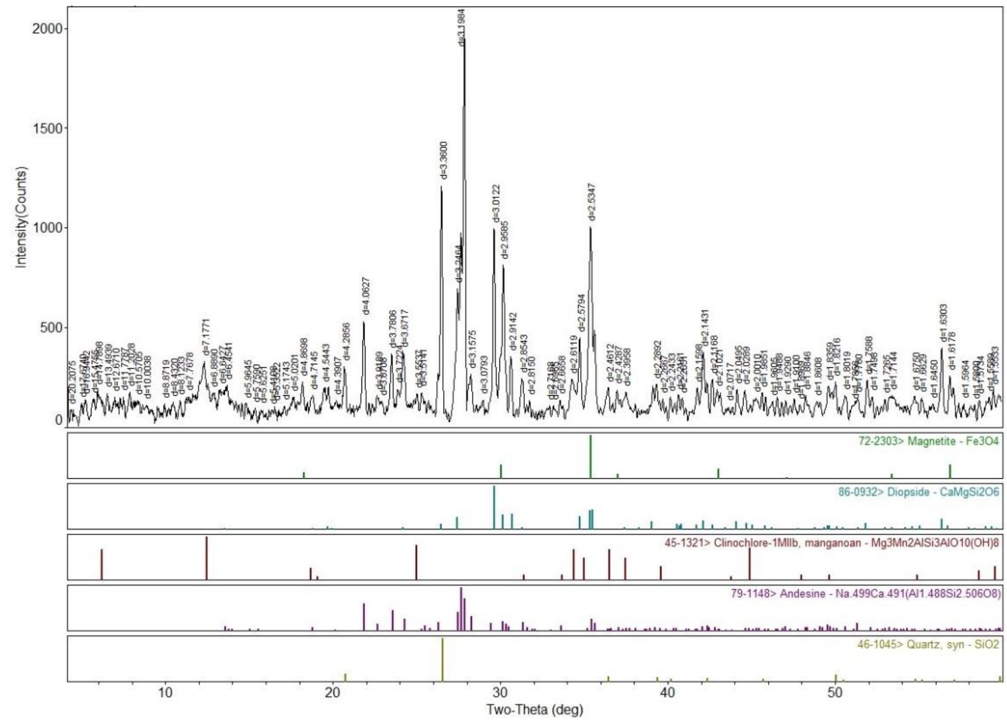

Figure S1. Typical XRD pattern of the fresh basalt in Shazi Sc deposit.

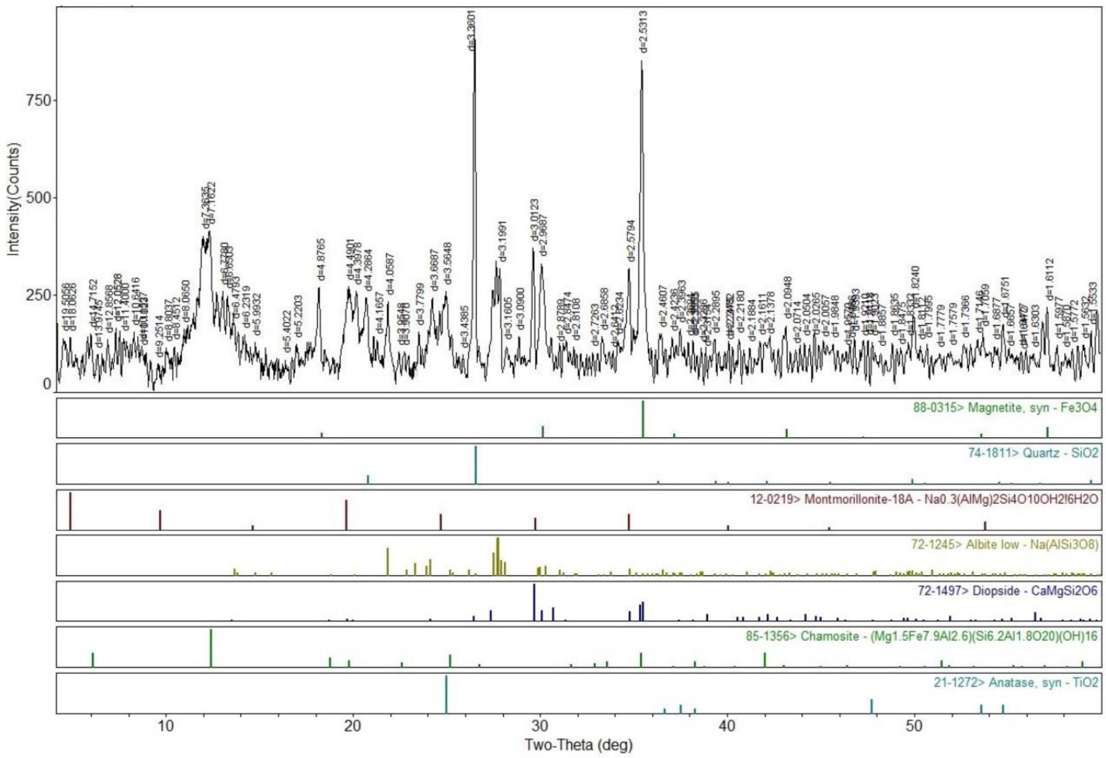

Figure S2. Typical XRD pattern of the weathered basalt in Shazi Sc deposit.

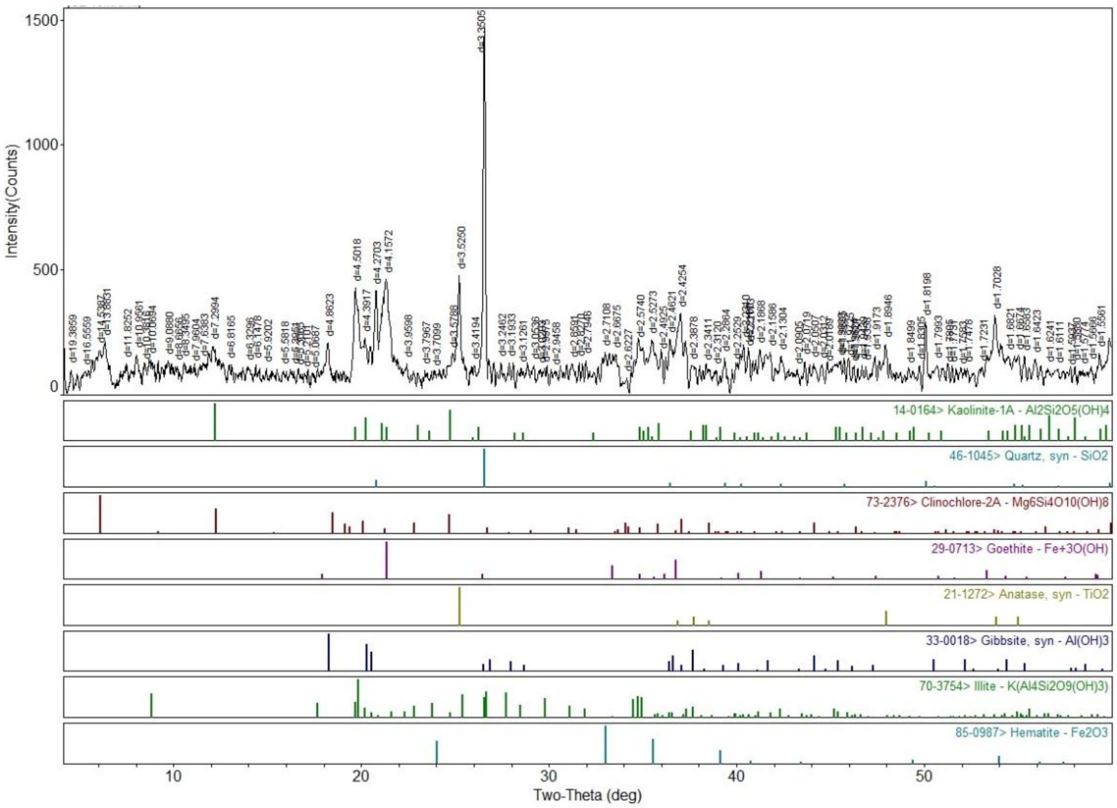

Figure S3. Typical XRD pattern of the laterite in Shazi Sc deposit.

2. major and trace compositions

All samples were crashed and powdered with an agate mill to 200-mesh. Major element abundances in whole-rocks were determined on fused glass discs using an AXIOS-PW4400 X-ray fluorescence (XRF) instrument in the State Key Laboratory of Ore Deposit Geochemistry (SKLODG), Institute of Geochemistry, Chinese Academy of Sciences. The accuracy was monitored using a Chinese national standard (GSR3). The standard deviations for the standard analyzed are generally better than 2%. The loss-on-ignition (LOI) was determined by the weight loss of a powered sample after one-hour heating at 1000°C 。

Trace element concentrations were analyzed using a Perkin-Elmer Sciex Elan DRC-e quadrupole inductively coupled plasma mass spectrometry (ICP-MS) in the SKLODG. 50 mg of powders for each sample were dissolved using a mixture of HF and HNO3 in Teflon bomb for 48 h at 190°C. Rh was used to monitor signal drift during data acquisition. The international standards GBPG-1 and OU-6, and the Chinese national standards GSR-1 and GSR-3, were used to monitor accuracy. The differences between our results and the recommended values for the standards are generally better than 10%.

These results are listed in table 1. As shown by Figure 4, although the mineral composition of basalt and weathered basalt has changed, there is little difference in composition. Compared with basalt, Al, Fe and Sc in laterite are enriched, and the enrichment factor of SC is about 2 times, while Si is lost.

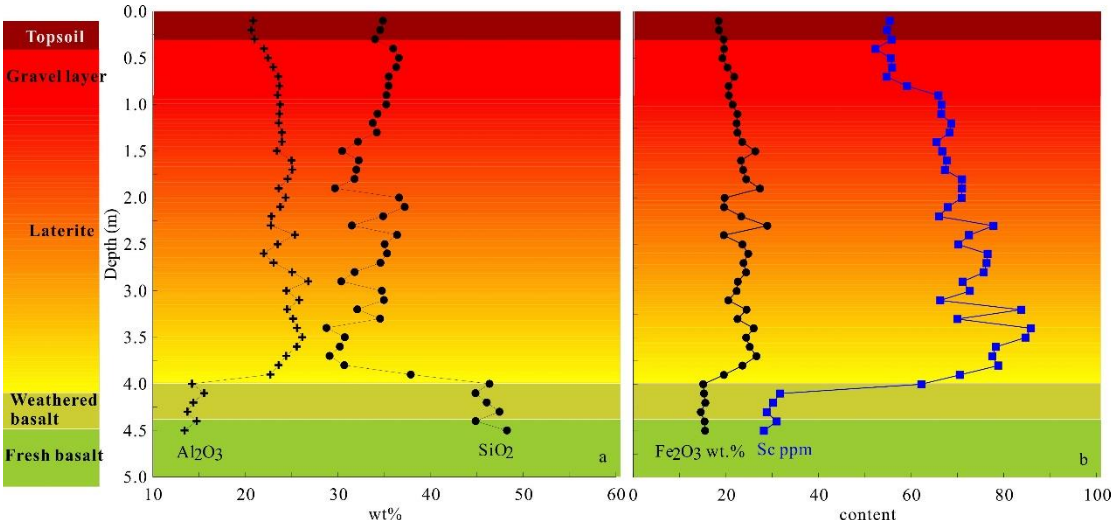

Figure S4. Geochemical evolution of a typical Sc-rich lateritic profile from Shazi deposit.

Table S1. the compositions of different sections of the laterite profile in the shazi deposit.

sample No.1	Depth (m)	rock type	**SiO_2**	**Al_2O_3**	**Fe_2O_3**	**MgO**	**CaO**	**Na_2O**	**K_2O**	**MnO**	**P_2O_5**	**TiO_2**	**LOI**	**SUM**	**Sc**
SZ-01	0.1	Topsoil	34.85	20.86	18.46	3.78	0.60	0.10	0.20	0.78	0.08	0.24	19.44	99.4	55.4
SZ-02	0.2		34.56	20.64	18.52	3.76	0.60	0.10	0.24	0.74	0.08	0.27	20.15	99.7	54.8
SZ-03	0.3		33.99	20.98	19.54	3.84	0.58	0.09	0.21	0.79	0.08	0.23	19.10	99.4	55.8
SZ-04	0.4	Gravel layer	35.97	22.02	19.61	3.87	0.65	0.08	0.20	0.85	0.08	0.18	15.81	99.3	52.3
SZ-05	0.5		36.57	22.46	19.26	4.25	0.74	0.04	0.24	0.81	0.07	0.17	15.36	100.0	55.6
SZ-06	0.6		36.29	23.02	20.35	4.00	0.67	0.07	0.14	1.04	0.07	0.14	13.55	99.3	55.9
SZ-07	0.7		35.49	23.57	21.82	4.19	0.62	0.09	0.11	1.01	0.07	0.13	12.91	100.0	54.7
SZ-08	0.8		35.46	23.68	20.60	4.22	0.61	0.09	0.10	0.91	0.06	0.13	13.06	98.9	59.1
SZ-09	0.9	laterite	35.23	23.49	20.65	4.18	0.62	0.08	0.12	0.94	0.06	0.14	13.20	98.7	65.9
SZ-10	1.0		35.22	23.75	21.46	4.33	0.57	0.07	0.09	0.78	0.07	0.13	12.93	99.4	66.6
SZ-11	1.1		34.27	23.69	22.52	4.65	0.62	0.04	0.22	0.75	0.07	0.13	13.22	100.2	66.5
SZ-12	1.2		33.75	23.61	22.33	4.41	0.54	0.07	0.05	0.80	0.07	0.12	13.30	99.1	68.7
SZ-13	1.3		34.19	23.95	22.52	4.38	0.56	0.08	0.06	0.91	0.07	0.12	13.17	100.0	68.3
SZ-14	1.4		32.16	23.97	23.53	4.35	0.57	0.07	0.01	1.03	0.07	0.11	13.13	99.0	65.5
SZ-15	1.5		30.45	23.40	26.37	4.23	0.55	0.07	0.04	0.96	0.11	0.11	13.10	99.4	66.7
SZ-16	1.6		32.23	24.99	23.27	4.35	0.56	0.06	0.02	0.96	0.16	0.12	13.09	99.8	67.7
SZ-17	1.7		31.98	25.06	23.74	4.39	0.56	0.06	0.02	1.03	0.11	0.12	12.96	100.0	67.3
SZ-18	1.8		31.79	24.57	24.40	4.32	0.54	0.06	0.02	0.89	0.09	0.12	12.67	99.5	71.0
SZ-19	1.9		29.68	23.60	27.36	4.38	0.53	0.06	0.05	1.20	0.07	0.11	13.56	100.6	71.0
SZ-20	2.0		36.60	24.36	19.73	4.96	0.48	0.07	0.14	0.57	0.07	0.16	12.61	99.8	70.9
SZ-21	2.1		37.21	23.78	19.62	4.76	0.47	0.07	0.11	0.59	0.08	0.13	12.72	99.5	67.9
SZ-22	2.2		34.87	22.82	23.32	4.72	0.52	0.03	0.24	0.51	0.05	0.13	12.90	100.1	66.0

SZ-23	2.3		31.50	22.76	28.95	4.94	0.43	0.06	0.31	0.21	0.23	0.30	10.69	100.4	77.8
SZ-24	2.4		36.38	25.35	19.56	4.95	0.41	0.06	0.23	0.18	0.10	0.23	12.53	100.0	72.5
SZ-25	2.5		35.04	23.50	23.58	4.81	0.43	0.02	0.22	0.18	0.07	0.28	10.72	98.8	70.2
SZ-26	2.6		35.30	21.99	24.84	4.47	0.44	0.06	0.41	0.16	0.12	0.34	11.77	99.9	76.5
SZ-27	2.7		34.58	23.05	23.82	4.65	0.44	0.05	0.32	0.18	0.07	0.31	11.96	99.4	76.3
SZ-28	2.8		31.80	25.05	24.38	4.76	0.47	0.07	0.27	0.27	0.10	0.27	12.17	99.6	75.7
SZ-29	2.9		30.36	26.80	22.59	5.47	0.40	0.06	0.37	0.29	0.16	0.43	13.96	100.9	71.1
SZ-30	3.0		34.74	24.43	22.34	4.42	0.47	0.06	0.28	0.33	0.12	0.27	12.19	99.7	72.7
SZ-31	3.1		34.96	25.81	20.52	5.28	0.41	0.06	0.25	0.20	0.11	0.29	12.34	100.2	66.3
SZ-32	3.2		32.08	24.51	24.46	5.16	0.57	0.05	0.29	0.20	0.12	0.35	12.51	100.3	83.8
SZ-33	3.3		34.55	25.15	22.51	4.69	0.46	0.06	0.34	0.26	0.18	0.33	12.36	100.9	70.0
SZ-34	3.4		28.76	25.58	26.01	5.24	0.44	0.06	0.34	0.31	0.20	0.39	13.05	100.4	85.9
SZ-35	3.5		30.73	26.16	24.38	4.90	0.43	0.06	0.26	0.28	0.43	0.39	12.59	100.6	84.7
SZ-36	3.6		30.21	25.55	25.16	4.82	0.47	0.06	0.22	0.41	0.26	0.32	13.01	100.5	78.3
SZ-37	3.7		29.10	24.41	26.62	5.46	0.68	0.10	0.42	1.25	0.25	0.47	12.17	100.9	77.5
SZ-38	3.8		30.68	23.59	23.59	4.90	1.49	0.29	0.49	1.42	0.39	0.45	12.09	99.4	78.8
SZ-39	3.9		37.86	22.70	19.56	3.94	1.55	1.02	0.54	1.18	0.56	0.34	10.24	99.5	70.5
SZ-40	4.0	weathered Basalt	46.36	14.25	15.12	3.44	4.51	8.76	2.53	1.00	0.17	0.34	3.14	99.6	62.2
SZ-41	4.1		44.84	15.56	15.28	3.58	4.45	7.84	2.48	1.04	0.17	0.35	4.20	99.8	31.7
SZ-42	4.2		46.06	14.39	15.57	3.38	4.59	8.56	2.78	0.70	0.21	0.33	3.09	99.7	30.2
SZ-43	4.3		47.43	13.74	14.60	3.14	4.77	9.32	3.08	0.62	0.22	0.33	2.23	99.5	28.8
SZ-44	4.4	Fresh Basalt	44.86	14.76	15.41	3.45	4.49	7.80	2.24	0.92	0.19	0.35	5.10	99.6	31.0
SZ-45	4.5		48.24	13.45	15.51	3.16	4.81	9.44	3.16	0.83	0.21	0.34	1.44	100.6	28.2