1. Analytical Methods

1.1. Mineral chemistry

1.1.1. Major element composition

Major element contents of feldspars, micas, chlorite, Fe-Ti oxides, zircon, rutile, apatite and titanite were determined using an electron probe microanalyzer (EPMA) with wavelength dispersive X-ray spectrometry (JEOL JXA-8600SX) housed at Niigata University, Japan. Operating conditions were 15 kV accelerating voltage, 13 nA beam current, and ~1 mm beam diameter. Data were corrected by oxide ZAF matrix correction. Some minerals (mica and chlorite) were determined using EPMA with wavelength dispersive X-ray spectrometry (JEOL JXA-8230-XM160041-0041) housed at the Graduate School of Science, Chiba University, Japan.The analytical conditions were 15 kV for acceleration voltage, 2.0 nA

for beam current, and 3 micron for the beam diameter. Fe-Ti oxides, accessory minerals, and rare metal-bearing minerals (eg. zircon, rutile, allanite, xenotime, and parisite) were carried out by means of thin-polished using ore microscopy and Scanning Electron Microscopy (SEM) coupled with Energy Dispersive X-Ray Spectroscopy (EDS) unit at Niigata University, Japan. The SEM/EDS unit operating conditions were 20 kV accelerating voltage, and working distance (WD) was 10 mm.

1.2. Trace element compositions

Representative trace-element concentrations of feldspar, muscovite, chlorite, zircon and parisite (Total 17 analyzed points) in both Umm Naggat and Homrit Waggat areas were determined in-situ by laser ablation-inductively coupled plasma-mass spectrometry (LA-ICP-MS) using a quadrupole ICP-MS (Agilent 7500a) coupled to a 213 nm Nd:YAG laser ablation system (New Wave Research UP213) at Niigata University, Japan. Analyses were carried out by ablating 50 to 80-μm diameter spots at 4 Hz with an energy density of 10 J/cm2 per pulse. The total time of data acquisition for one spot is 105 seconds including laser ablation for 45 seconds and background for 40 seconds. The CaO and SiO2 contents of silicates as well as Al2O3, FeO2 and TiO2 of oxides determined by electron microprobe were used as an internal standard for quantification of silicates and iron oxides. SRM 612 and SRM 610 (Pearce et al. 1997) were used as external standards for calibration of trace element concentrations.

1.3. Whole rock chemistry

Concentrations of major oxides, trace elements, and REEs were analyzed for granitic samples (19 samples) in the Igla Ahmr area and are listed in Supplementary Table 4. XRF and ICP-MS analyses were carried out at the GeoAnalytical Lab, Washington State University (WSU), USA. An agate-grinding bowl was used to crush the sample into homogenized pebble-sized particles and subsequently pulverized. The concentration of major and few trace elements was determined via X-ray fluorescence (ThermoARL XRF Spectrometer). Each powdered sample was weighed, mixed with two parts di-lithium tetraborate flux, fused at 1000°C in a muffle furnace, and cooled. The resulting bead was reground, re-fused, and polished on diamond lap to produce a smooth, flat surface for analysis. The calibration standard was the reference material 650 CC from the USGS standard rock powder GSP2. The detection limit for major oxides and trace elements is available online from the GeoAnalytical Lab. Loss on ignition (LOI) was determined by weight difference after ignition at 1000 °C.

Concentrations of REEs and trace elements were determined via ICP-mass (Agilent 7700 ICP-MS) spectrometry. About 50 mg powder of each sample was dissolved in acid-washed Teflon containers by refluxing in hot (250 °C) 3:1 nitric and hydrofluoric acid for at least 8 hours. A working curve for instrument sensitivity was developed using a blank fused bead from the same batch of flux as used to prepare the unknowns along with USGS

standards AGV-2 and RGM2. Additional USGS standards (DTS-2, BCR-1, G-2) were used as a reference for quality control.
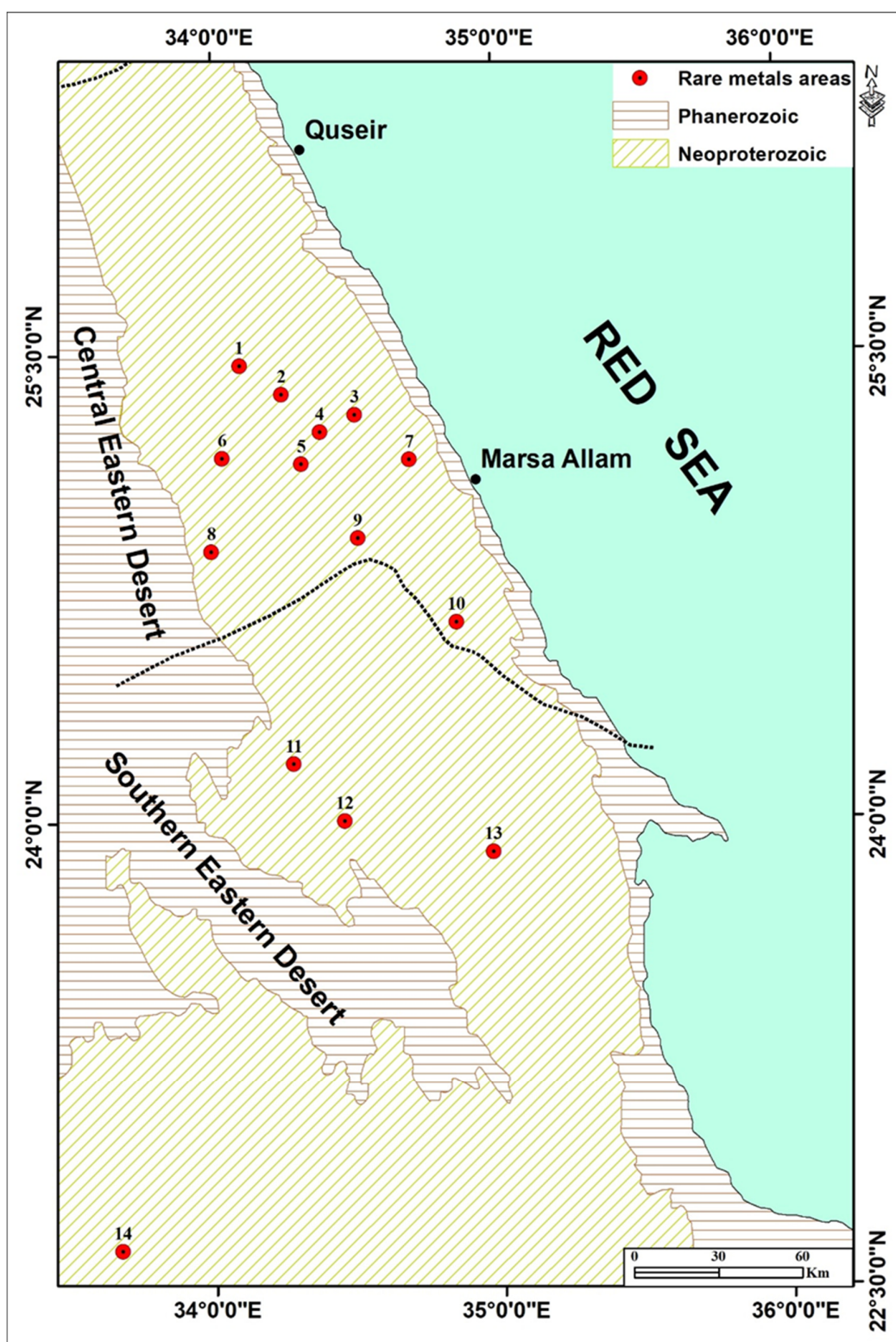
Figure S1. Distribution of the most important rare-metal-bearing granite intrusions in the central and south Eastern Desert of Egypt: (1) Umm Naggat, (2) Umm Samra, (3) Abu Dabbab, (4) Nuweibi, (5) Ineigi, (6) Homrit Waggat, (7) Igla, (8) Zabara, (9) Mueilha, (10) Nugrus, (11) El- Gharabiya, (12)

Nikeiba, (13) Homrit Akarem, and (14) Um Hibal. The dividing line between the central and southern portions of the Nubian Shield is after Stern and Hedge (1985).
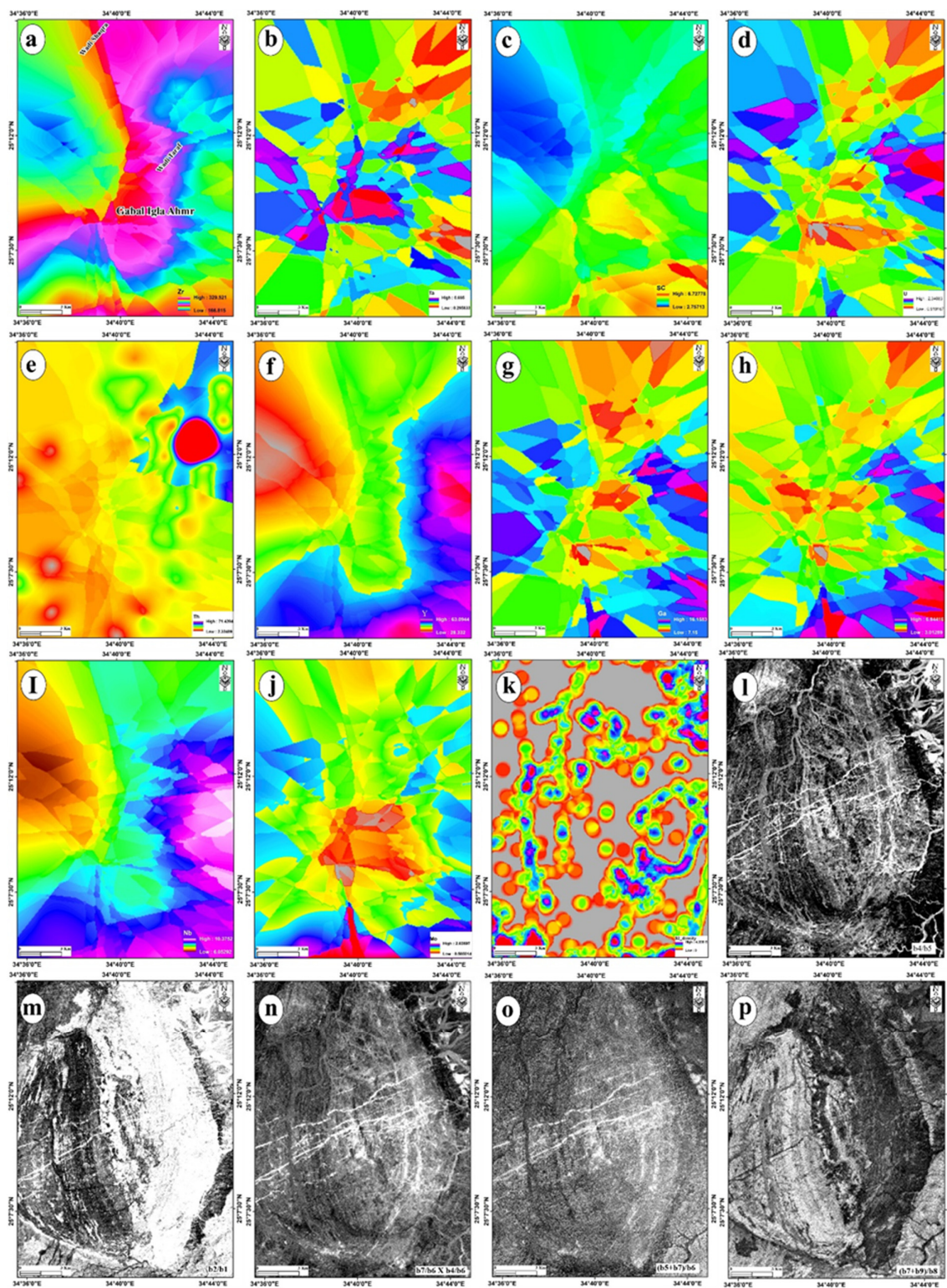
Figure S2. (**a-j**) Geochemistry evidence layers using kriging interpolation. (**K**) Line density map of Igla Ahmr area. (**i-p**) Five alteration indices in the Igla Ahmr area.
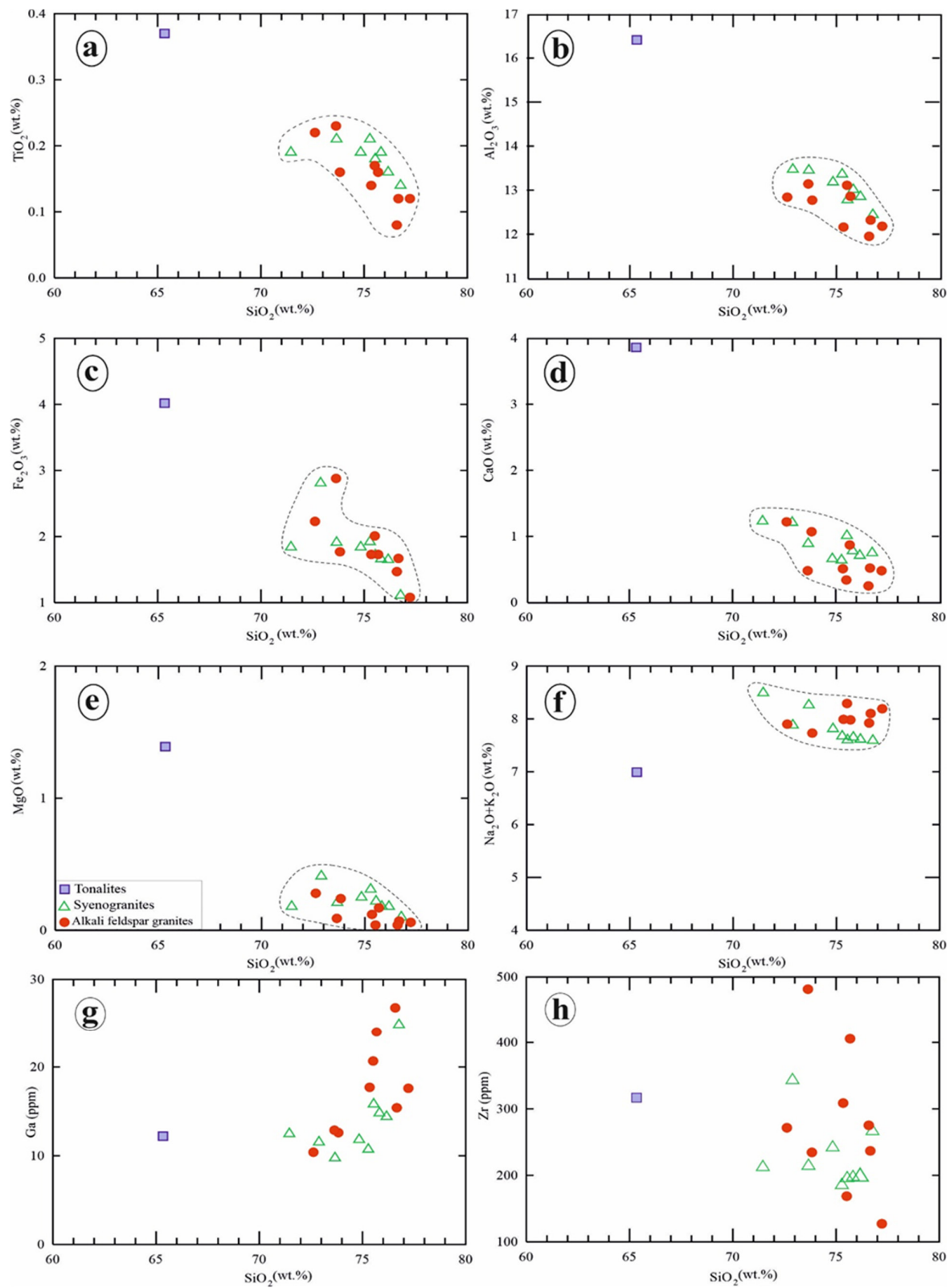
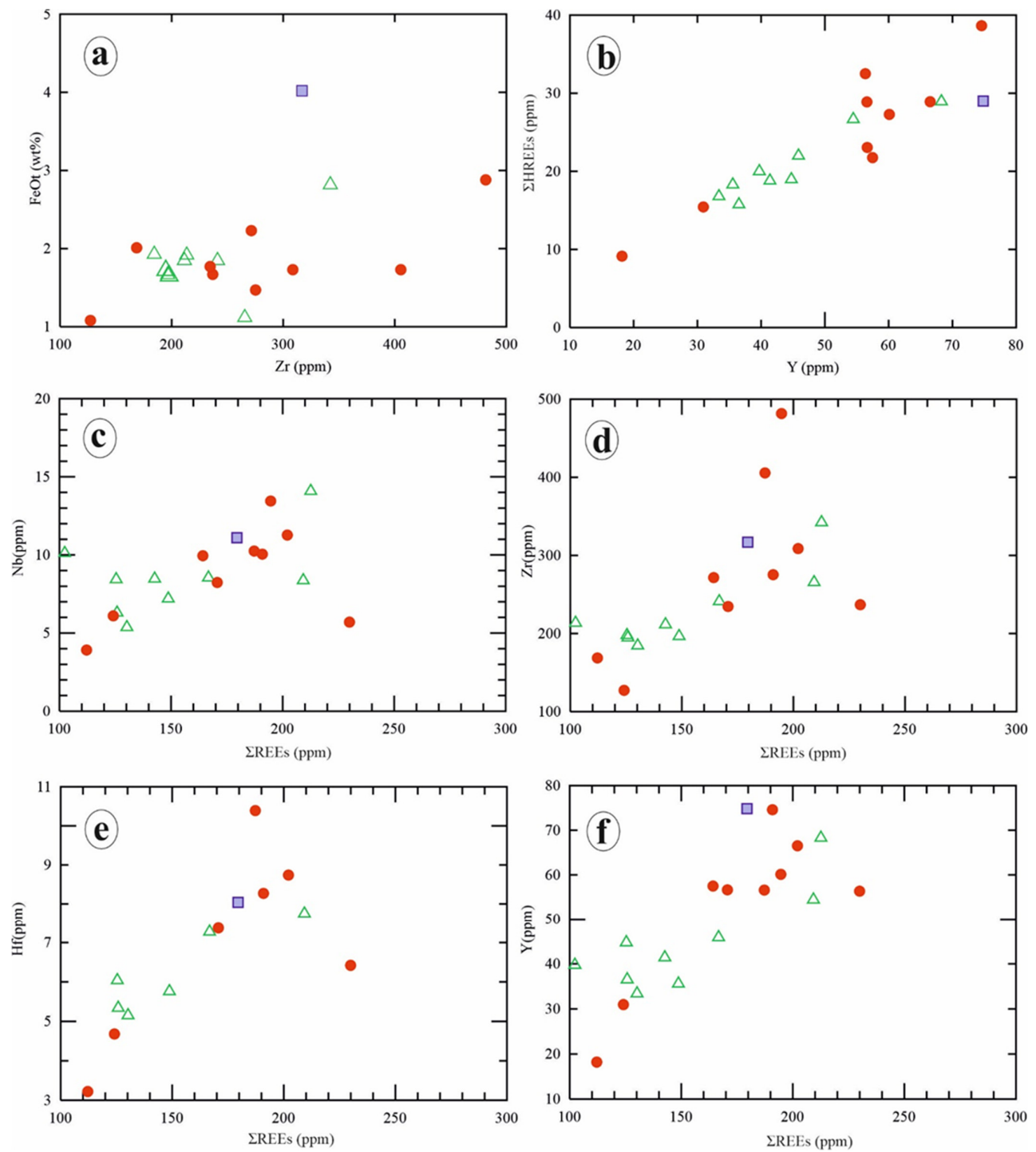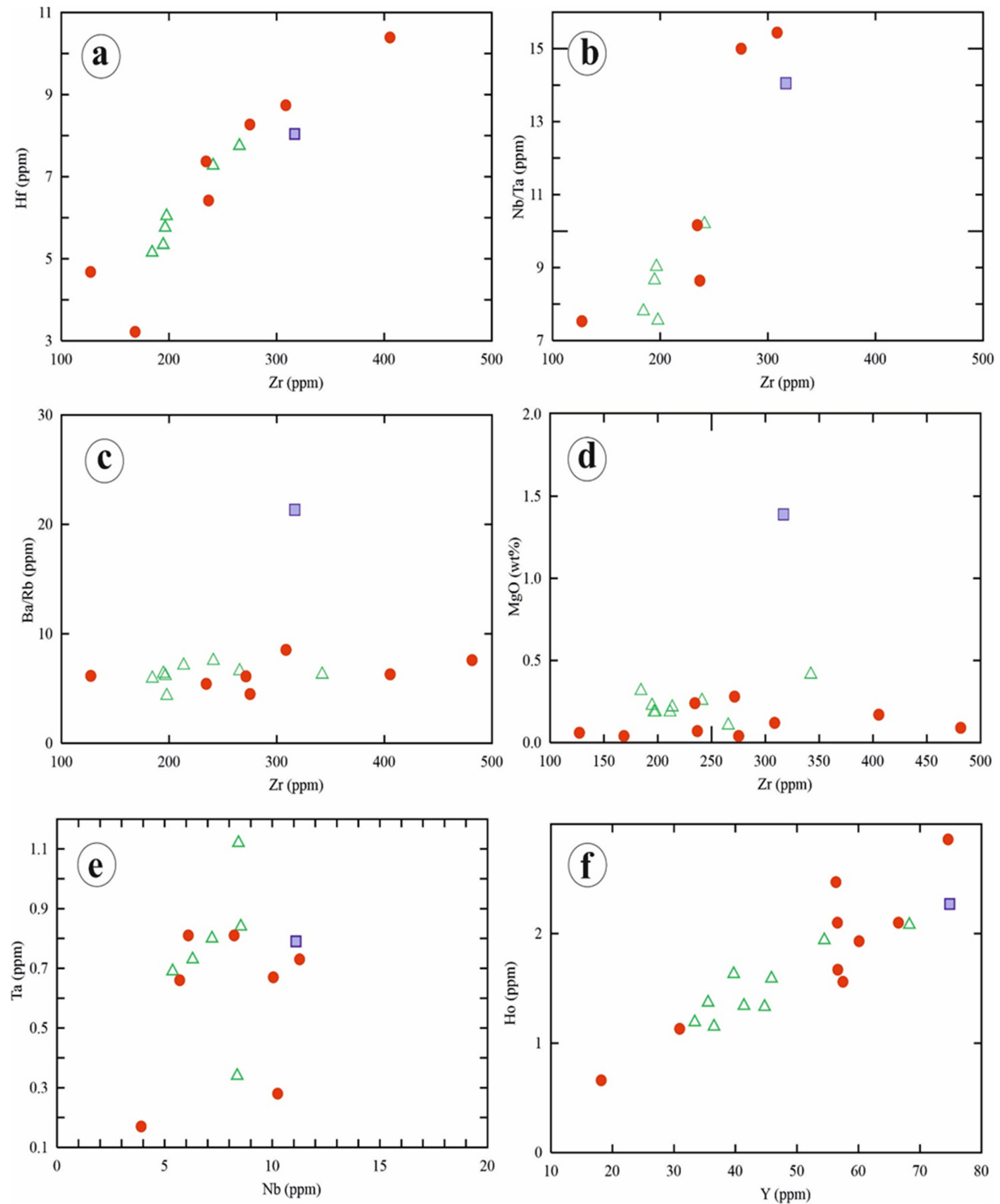**Figure S3.** Harker variation diagrams of SiO₂ versus major elements and trace elements (Ga and Zr).

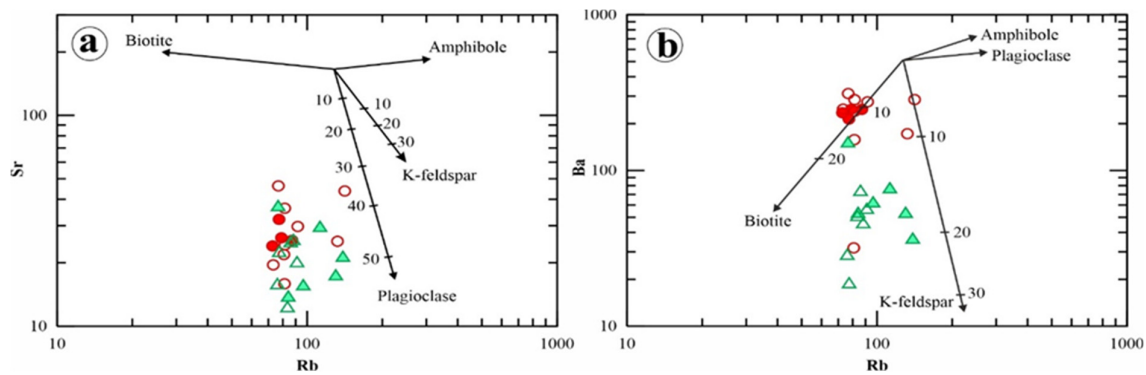**Figure S4.** Variation diagrams of Zr versus FeOt (**a**), and ΣHREEs versus Y (**b**), as well as ΣREEs versus Nb(**c**), Zr(**d**), Hf (**e**) and Y (**f**) in the Igla Ahmr granites.

Figure S5. Variation diagrams of Zr (ppm) versus Hf (**a**), Nb/Ta (**b**), Ba/Rb (**c**) and MgO (**d**), as well as Nb versus Ta (**e**) and Y versus Ho(**f**) in the Igla Ahmr granites.

Figure S6. Sr versus Rb (**a**) and Ba versus Rb (**b**) diagrams, showing that fractional crystallization of plagioclase, K-feldspar and biotite played an important role in the generation of the Igla Ahmr granites. The Keskin (2002) software was used to model the Rayleigh fractionation vectors.

References

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