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# The Effects of Wildfire on the Magnetic Properties of Soils in the Everglades

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## Introduction

As part of an effort to better understand the role of wildfire in the Everglades ecosystem, we are studying the effects of fires on the magnetic properties of Everglades soils. We present results from a suite of soil samples collected at vegetation survey sites within the Cape Sable seaside sparrow (CSSS) habitat in southern Everglades, for which vegetation data, hydrologic data, organic carbon content, iron concentration and the fire history of the sites (burn frequency and time since the most recent burn) are available (Figure 1).

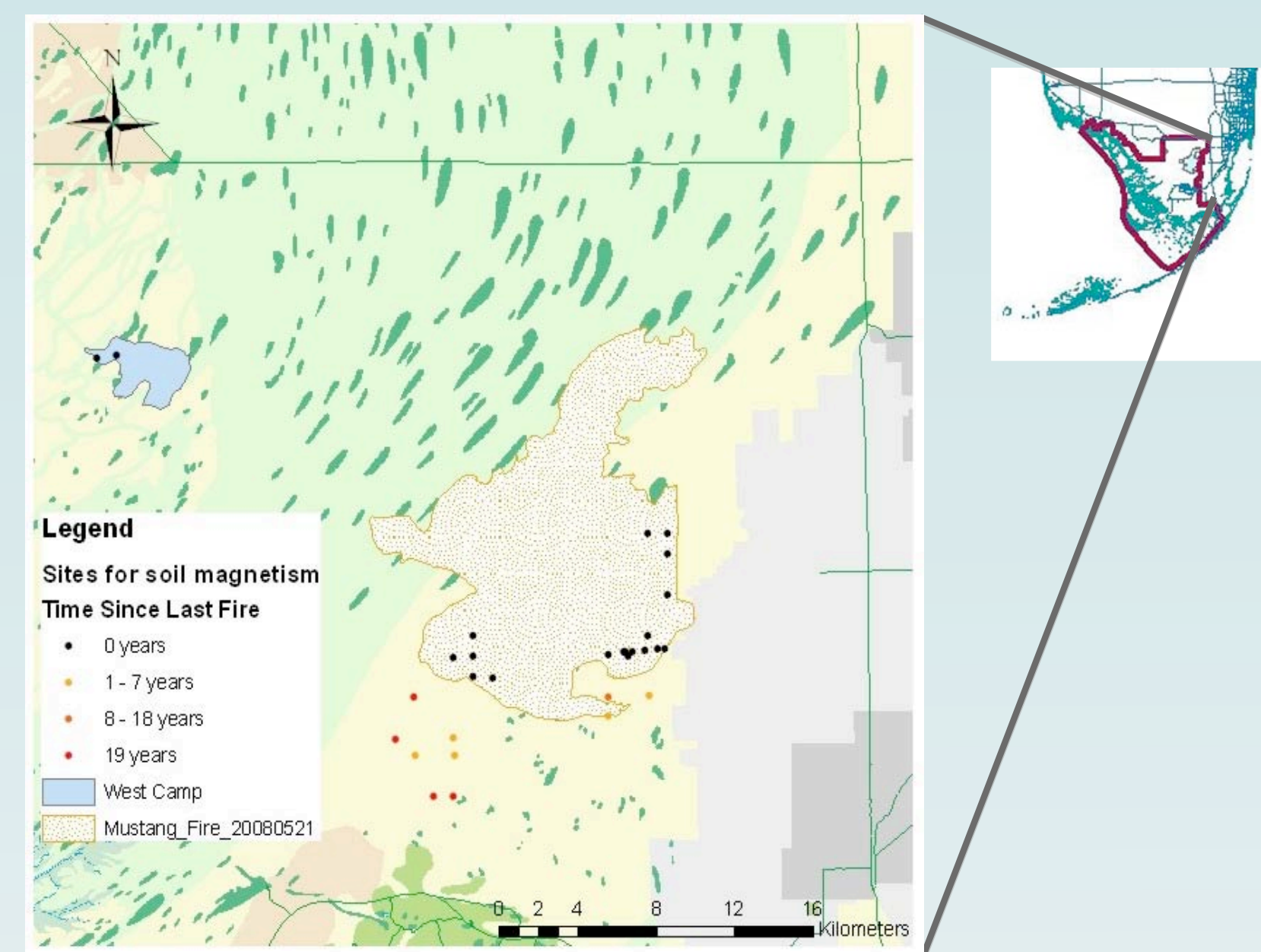


Figure 1. Locations of sites sampled in the Summer of 2008. Also shown are the areas burned in the West Camp and Mustang Corner fires of Spring 2008.



Figure 2. The Mustang Corner fire burning in Spring of 2008 (left). Coring sediment at a burned site in Summer of 2008 (right).

## Methods

Following a major fire in the late Spring of 2008, we collected 20 soil cores (10–13 cm) from within the fire boundary, and 10 cores from nearby unburned sites (Figures 1 and 2). At each site the intensity of the fire was estimated by measuring the percent surface area that was burned in a 6 m x 1 m transect. Each core was sub-sampled from the surface, and from 2 cm depth and from between 7 to 13 cm depths. The samples were subjected to a suite of rock-magnetic measurements (initial susceptibility, frequency-dependent susceptibility, anhysteretic remanence acquisition and isothermal remanence acquisition) designed to identify the major magnetic minerals present in these soils and to constrain their relative concentrations. Of these measurements, Isothermal Remanence Acquisition (IRM) curves proved to be the most useful because of the importance of very high coercivity components (> 3 Tesla) that could not be detected using other types of measurements.

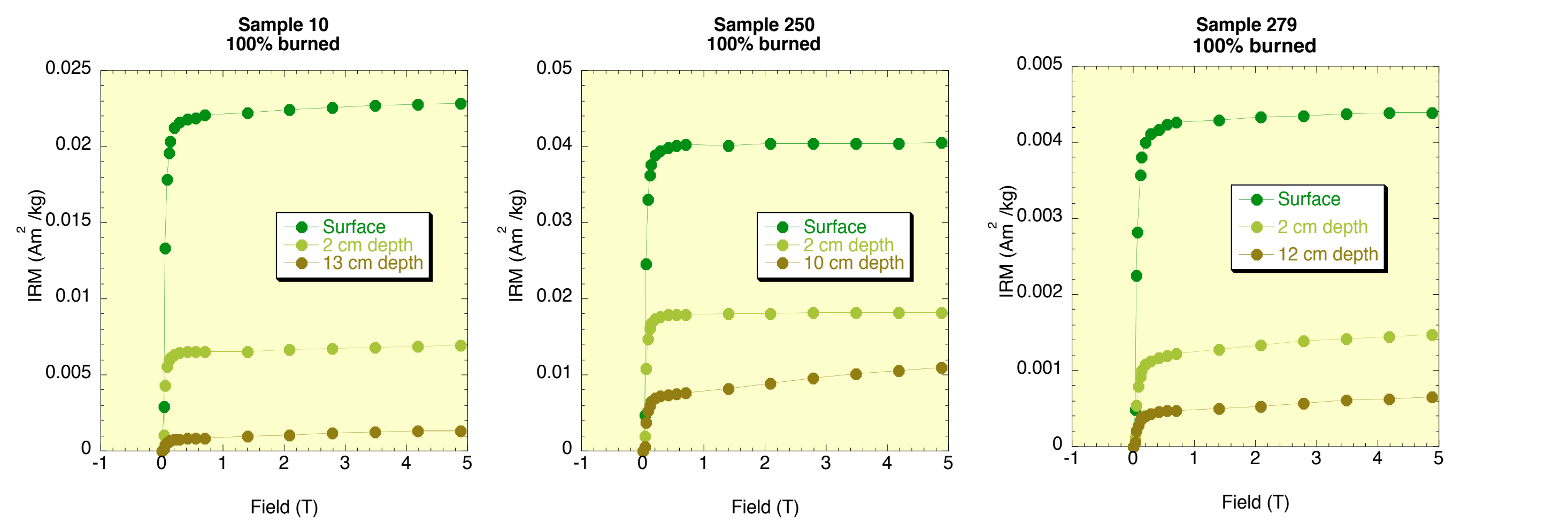


Figure 3. Cores collected from sites characterized that had been 100% burned during the 2008 fire exhibit a large surface magnetic enhancement effect. The surface samples exhibit sIRMs that are dominated by low-coercivity carriers and that are many times more magnetic than observed at depth in the same cores.

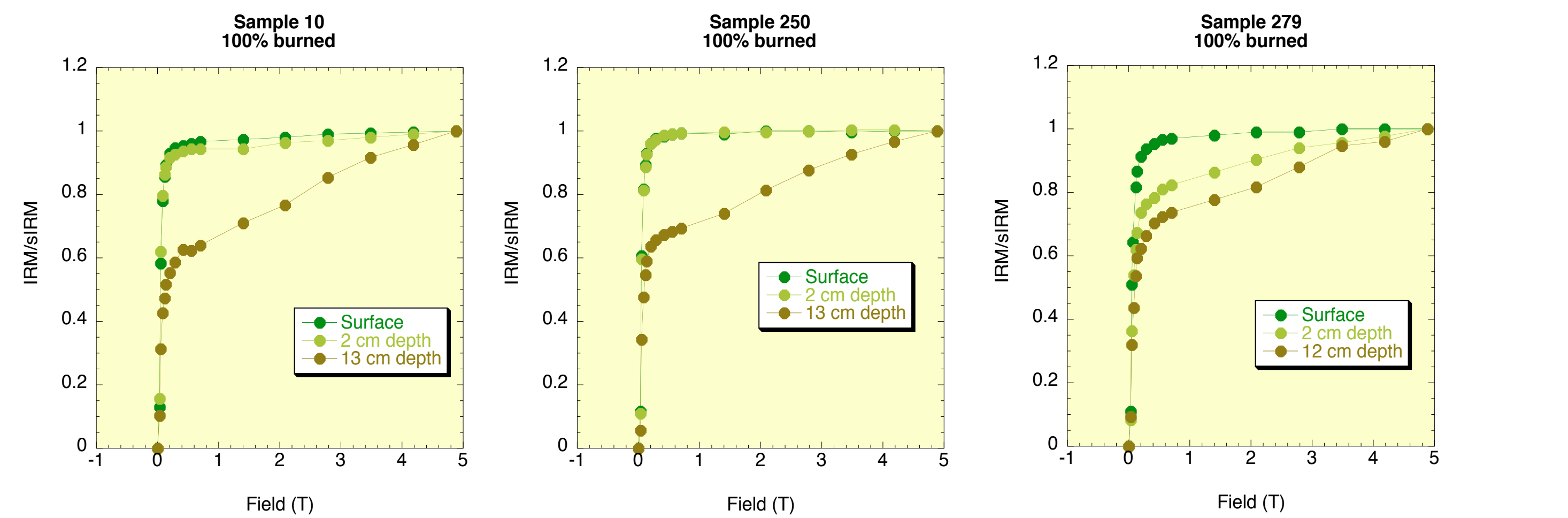


Figure 4. The increase in sIRMs in the surface samples does not result solely from an increase in the concentration of the magnetic carrier. Instead, the composition of the magnetic carrier varies systematically with depth. Deeper samples contain a progressively greater amount of a very high coercivity carrier(s). In these samples, the IRMs do not saturate even in impulse field approaching 5 Tesla, suggesting that the remanence is carried by goethite.

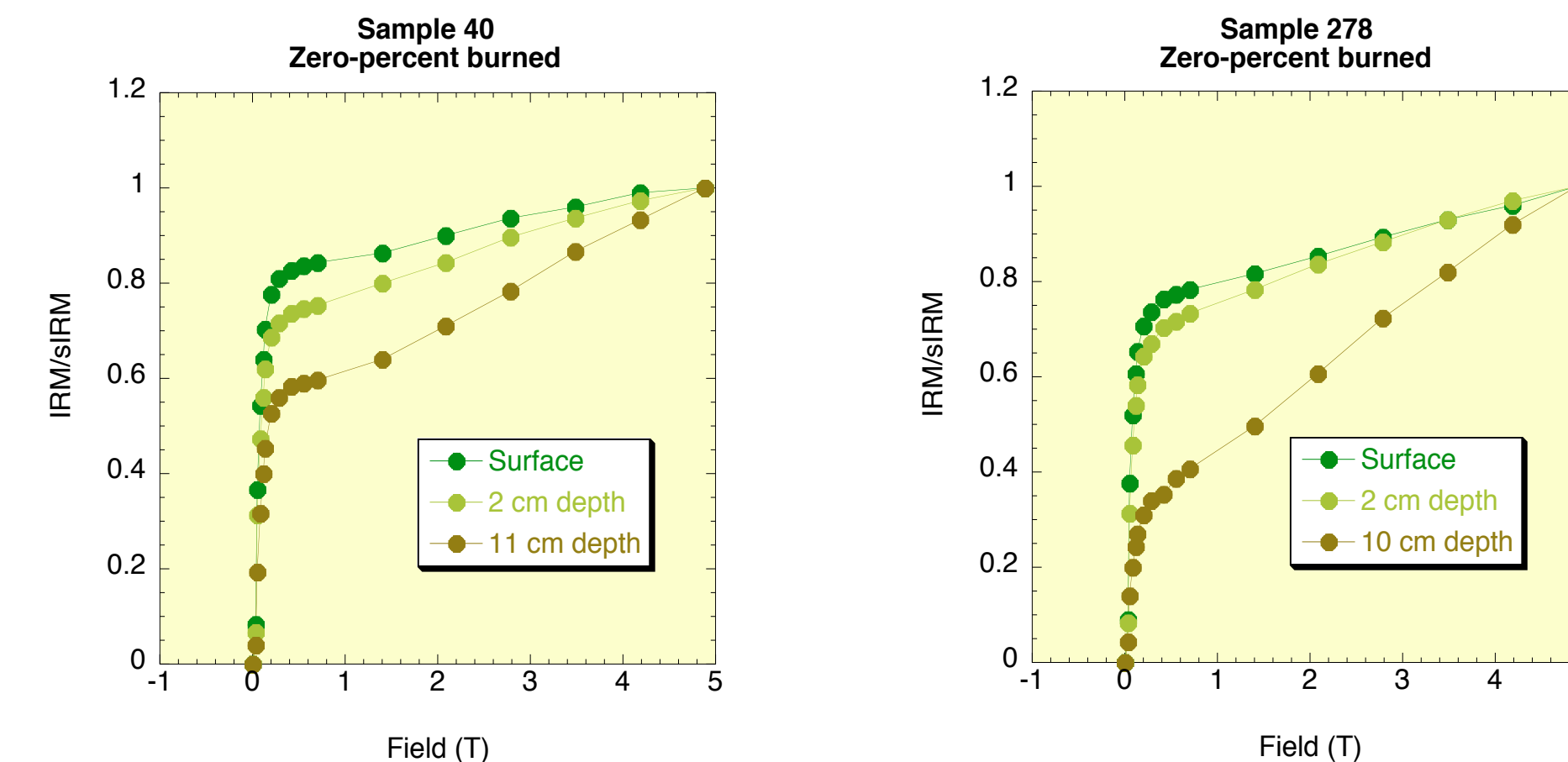


Figure 5. Cores collected from the same area that were not affected by the fire (0% burn), show high coercivity magnetizations in the surface samples. The sIRMs of the surface samples are often less than the sIRMs of deeper samples. These results suggest that the fire has caused the enhancement of the surface magnetization by converting the high coercivity carrier to a lower coercivity carrier.

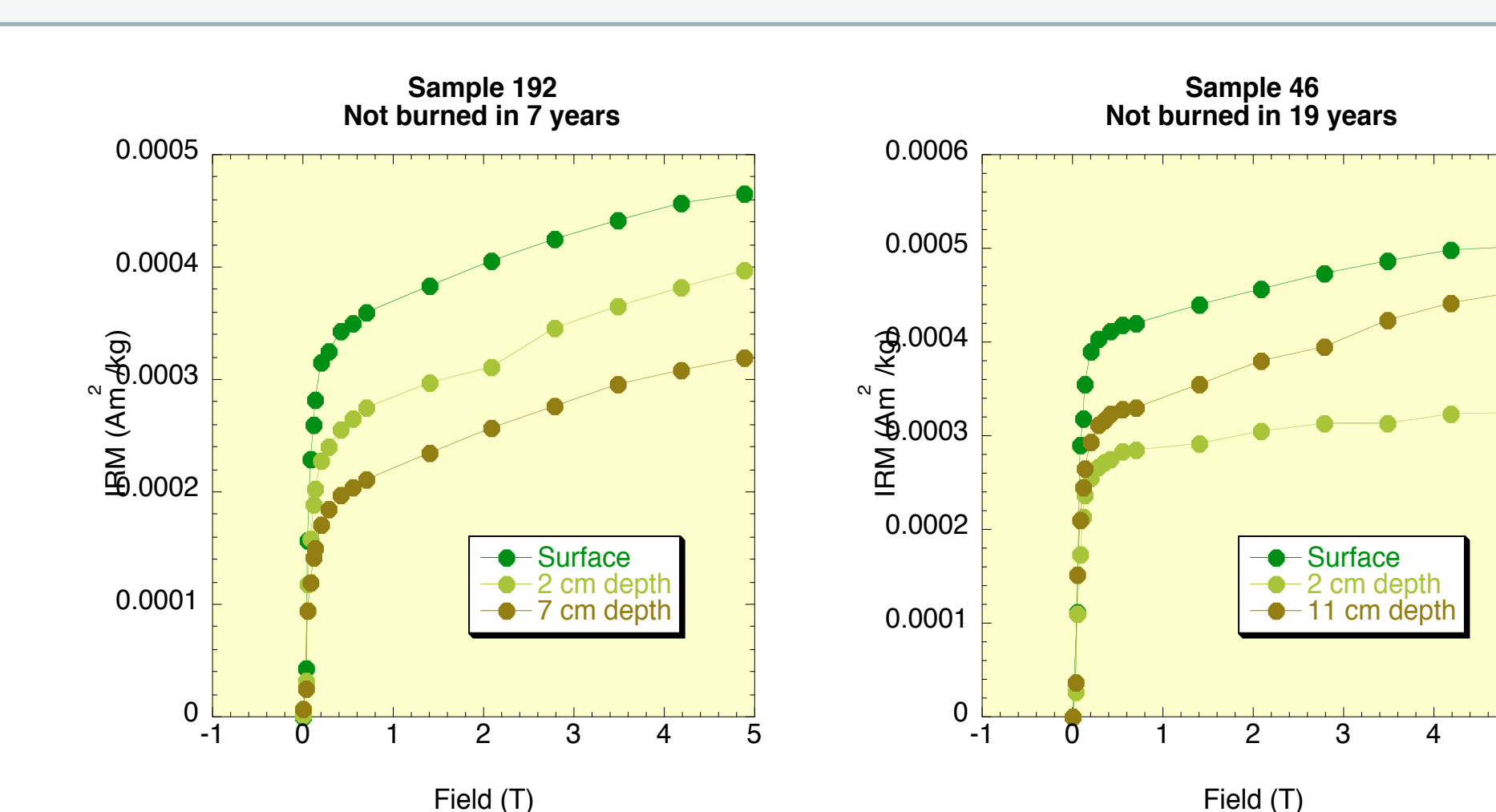


Figure 6. Cores collected from areas that have not been burned in 7 years and 19 years also exhibit magnetizations that are dominated by high-coercivity carriers, even at the surface. The sIRMs in these samples do not always show a systematic variation with depth downcore.

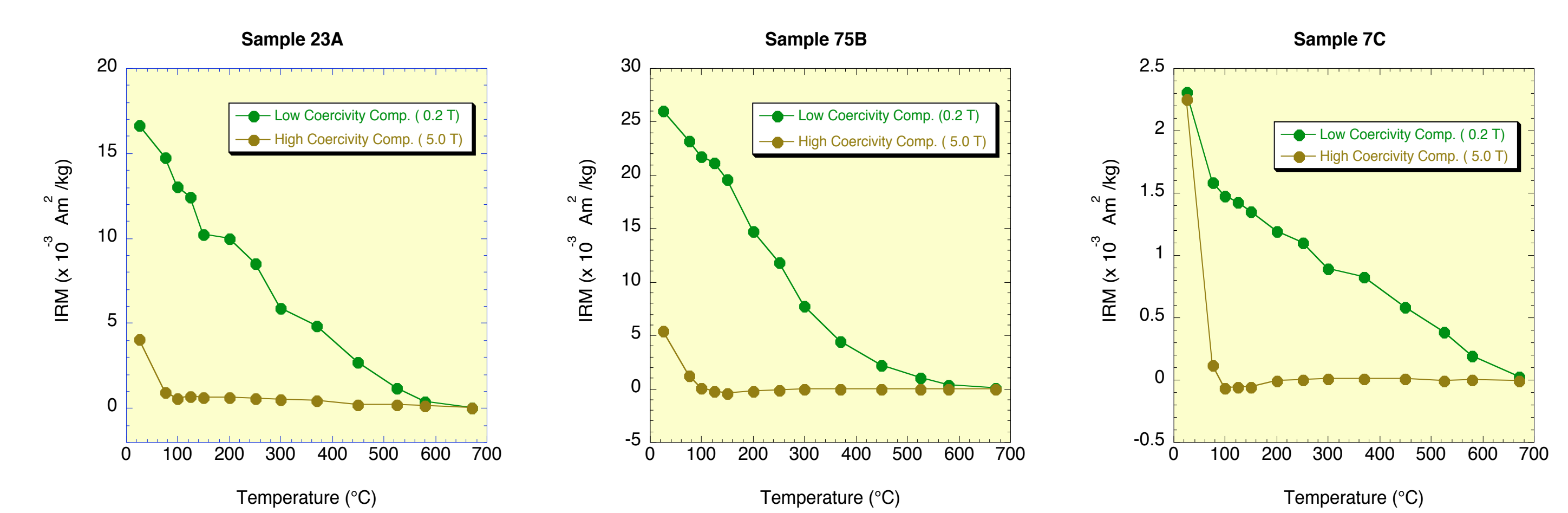


Figure 7. The high coercivity magnetization is carried by goethite. Progressive thermal demagnetization of orthogonal 2-component IRMs imparted at 5 Tesla and 0.2 Tesla show that the high coercivity component is completely unblocked at temperatures of 100°C to 125°C – the maximum unblocking temperatures of goethite. The low coercivity magnetizations are completely unblocked at ~580°C indicating that this component is carried by magnetite. In one sample, the low-coercivity component is not unblocked until treatment at 670°C (indicating a hematite remanence). The hematite likely formed during thermal demagnetization as maghemite was converted to hematite above temperatures of 350°C.

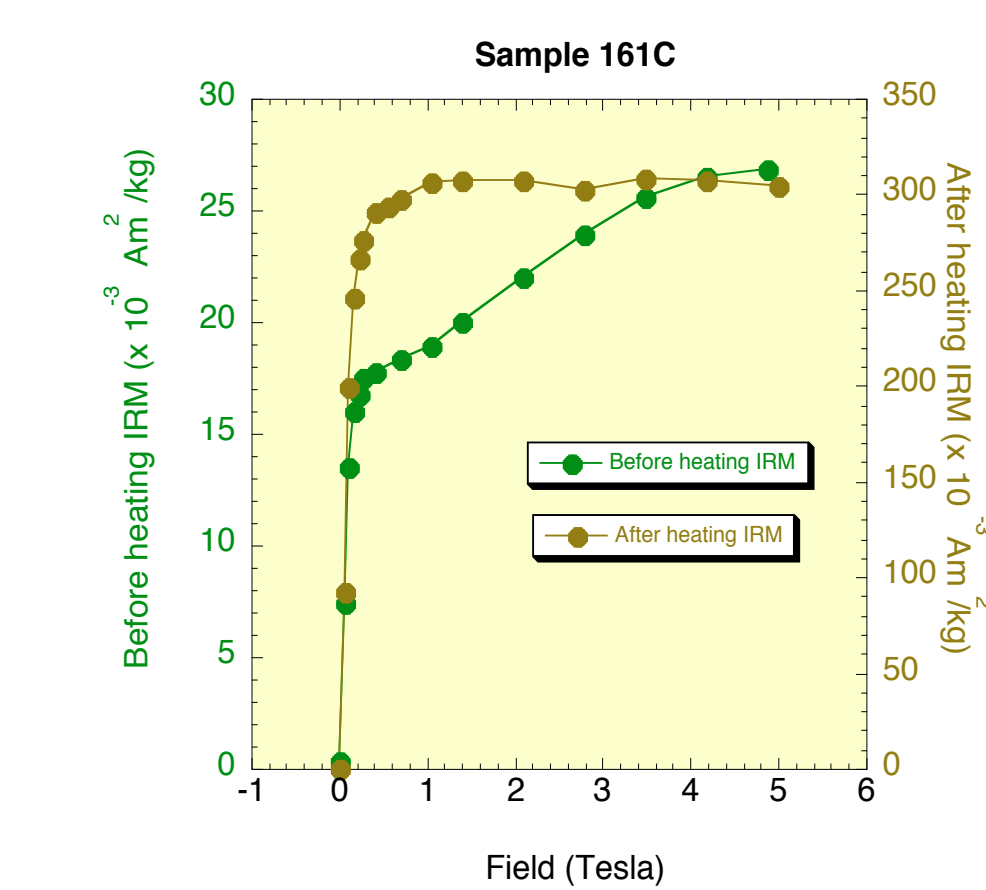


Figure 8. Comparison of IRM acquisition curves imparted before and after thermal demagnetization show that the high coercivity carrier (goethite) is destroyed during heating and replaced by a low coercivity carrier (magnetite/maghemite) with a resulting sIRM that is more than 10 times greater than the pre-heating sIRM.

## Conclusions

### Enhancement of the surface magnetization is caused by conversion of goethite to magnetite/maghemite:

Heating during wildfire causes the magnetization of surface soils in the Everglades to be significantly increased. This increase occurs as goethite is dehydrated and is replaced by low-coercivity carriers such as magnetite/maghemite. Goethite is a common mineral in Everglades soils and rocks precipitating on surface materials as the water table seasonally falls below the surface.

### A potential tool for determining the intensity of a fire in the Everglades:

The depth range over which goethite is lost may provide a useful measure of the intensity of a fire. The presence/absence of hematite may provide an upper boundary on the temperature reached during the fire.

### The effects on phosphorous cycling:

Iron oxyhydroxides, such as goethite, are known to be important adsorbers of phosphorous. The results presented here demonstrate that heating surface soils during wildfire converts goethite to magnetite/maghemite. The destruction of goethite will release the phosphorous that had been adsorbed onto it. Therefore these results may have important implications for our understanding of the role of fires in the phosphorous cycle.