Biomarker (brGDGT) degradation and production in lacustrine surface sediments.

We know that:
I. Branched GDGTs (brGDGTs) are membrane lipids produced by heterotrophic bacteria.
II. The distribution of brGDGTs in lake surface sediments (summarized in the MBT' 5ME ratio) is related to mean annual temperature (Russell et al., 2018).
III. Heterotrophic bacteria are also present and active downcore in lake sediments (i.e. Fiskal et al., 2019).

Question: Is the downcore lacustrine brGDGT signal (and the temperature record) influenced by in-situ bacterial lipid production?

Approach:
Measure fossil (core lipid [CL]) and recently produced (intact polar lipid [IPL]) distributions in top 30-40 cm of lake sediments and compare their distribution.

Conclusions
A clear subsurface maximum in brGDGT intact polar lipids is observed. This IPL signal will contribute to the total lipid extract when using standard high temperature extraction protocols.
The GDGT0/crenarchaeol ratio indicates subsurface methanogenesis at distinct sedimentary horizons.

Lake Baldegg - Eutrophic - Seasonal anoxic water column (artificial aeration)
Core collected at 21 m water depth - Sediments anoxic below 0.1 cm bfl - Max. sediment age ~ 150 yr.

Lake Luzern - Oligotrophic - Oxic water column
Core collected at 24 m water depth - Sediments anoxic below 0.5 cm bfl - Max. sediment age ~ 190 yr.

Although most microbial degradation of OM happens in top 5 cm (decrease in TOC), the percentage of brGDGT lipids produced recently (IPL) increases in deeper sediments (>15 cm). This increase in % IPL correlates with an increase in brGDGT IIa (%) in the core lipid fraction. The distribution of core lipid (CL) brGDGTs changes downcore, with an increase of brGDGT IIa. Compared to the CL fraction, the intact polar lipid (IPL) show increased amounts of Ia and IIa, resulting in increased MBT' 5ME values. The sediments deposited in a period of increased P influx (orange) show no distinct signal.

Although most microbial degradation of OM happens in top few cm (increase in TOC), the percentage of brGDGT lipids produced recently (IPL) increases in deeper sediments (>20 cm). This increase in % IPL correlates with an increase in brGDGT la (%) in the core lipid fraction. The distribution of core lipid (CL) brGDGTs changes downcore, with a decrease of brGDGT IIa (%). Sediment horizons with a decreased amount of brGDGT IIa (%) are encountered, resulting in variable MBT'5ME values. Compared to the CL fraction, the intact polar lipid (IPL) show slightly increased amounts of brGDGTs Ia, Ila and Ila'.

Proxy 2: Archaeal isoprenoid GDGT lipids.
In lake sediments, the presence of GDGT0/crenarchaeol values > 2, indicate the presence of methanogenic Archaea. Methanogens produce CH₄ in anoxic conditions, and will be more abundant in eutrophic lake settings.

Lake Luzern IPL and CL distributions show a distinct horizon of methanogenic archaeal activity. The IPL signature is present at more shallow depths (younger sediments) than the CL fraction. Sediments deeper than 17 cm show an lipd distribution that does not reflect the presence of methanogens, although CH₄ concentrations continue to rise.

Lake Baldegg has high GDGT0/cren values, especially in the IPL fraction, that are typical for eutrophic lakes with a high methanogenic activity. A maximum is observed in sediment depth between 20-35 cm bfl. In deeper sediments (>40 cm bfl) the GDGT0/cren ratio drops, indicating a change in the archaeal community composition.