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Origin and implications of a thrust-bound gypsiferous unit along the western edge of Jabal Sumeini, northern Oman Mountains

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ABSTRACT

The Oman Mountains comprise a series of thrust sheets of Neo-Tethyan oceanic rocks that were emplaced onto the Arabian continental margin during obduction of the Semail Ophiolite during the Late Cretaceous. Three separate groups of anomalous gypsiferous bodies intrude the allochthonous units along faults over a distance of about 150 km in the Hawasina Window, Jabal Qumayrah and Jabal Sumeini. The bodies at Jabal Sumeini form a band about 4 km long and up to 100 m wide along a late-stage thrust that restacks the allochthon over a post-emplacement Maastrichtian-Palaeogene sedimentary succession. The gypsum shows evidence of flow-folding and contains numerous clasts and rafts of a range of quartzose sandstones, but with only a minor component from carbonates from the Neo-Tethyan Sumeini Group in the hanging-wall. Palaeogene limestones from the footwall succession are essentially absent. Strontium isotope ratios are high and intersect with the open ocean-water reference curve for the Late Cambrian-Ordovician and Late Miocene-Pliocene. They are also noticeably higher than the ratios from the two other gypsiferous outcrop areas in the Oman Mountains and from outcrops of Ediacaran-Early Cambrian salt domes in central Oman. However, the regional stratigraphy points towards a source of the gypsum from either an Ediacaran-Early Cambrian Ara Group salt basin or from the Lower Fars Formation (Early-Middle Miocene), and derivation of the sandstone clasts and rafts from thick Lower Palaeozoic clastic sequences. The discrepancy with the ages inferred from the strontium isotope data can be attributed to deposition of the gypsum in restricted conditions not in equilibrium with the prevailing ocean water. Two models are presented, for an Ediacaran-Early Cambrian and an Early-Middle Miocene source. While the latter cannot be wholly discounted, the stratigraphic and structural context point more strongly towards an Ediacaran-Early Cambrian Ara Group source of the gypsum. This was extruded along deep-rooted Late Cretaceous thrust faults that were reactivated during a period of Cenozoic compression, incorporating Lower Palaeozoic sandstone clasts from adjacent strata during extrusion, or during an earlier phase of possible halokinesis. This is consistent with existing models for the emplacement of the other two identified groups of gypsiferous bodies in the Oman Mountains and provides further evidence for the presence of smaller evaporite basins between the major Hormuz and central/ southern Oman salt basins.

1. Introduction

In recent years, a number of anomalous gypsiferous bodies have been identified within the allochthonous units of the Oman Mountains at Jabal Qumayrah, in the Hawasina Window, and at Jabal Sumeini (Fig. 1, Csontos et al., 2010; Cooper et al., 2012, 2013; Ali et al., 2014a). Analyses of the bodies at Jabal Qumayrah (Cooper et al., 2013) and the Hawasina Window (Ali et al., 2014a) suggest their origin is Ediacaran to Lower Cambrian in age, before being brought to the surface during the later Palaeogene or Neogene along faults. They were most probably derived from previously undocumented extensions of the Ara Group salt basins in central Oman (Fahud and Ghaba Salt Basins) and the northern United Arab Emirates (Hormuz Salt Basin).

The gypsiferous unit at Jabal Sumeini is superficially very similar in appearance to those in Jabal Qumayrah and the Hawasina Window, 90 km and 150 km to the south and SE respectively. It is a fault-bound unit that comprises mainly gypsum and anhydrite. It contains exotic clasts derived in comparatively small volumes from the local host rock. Most are from sources distinct from the host lithologies. There are also notable differences. In particular, while all three locations are late-stage

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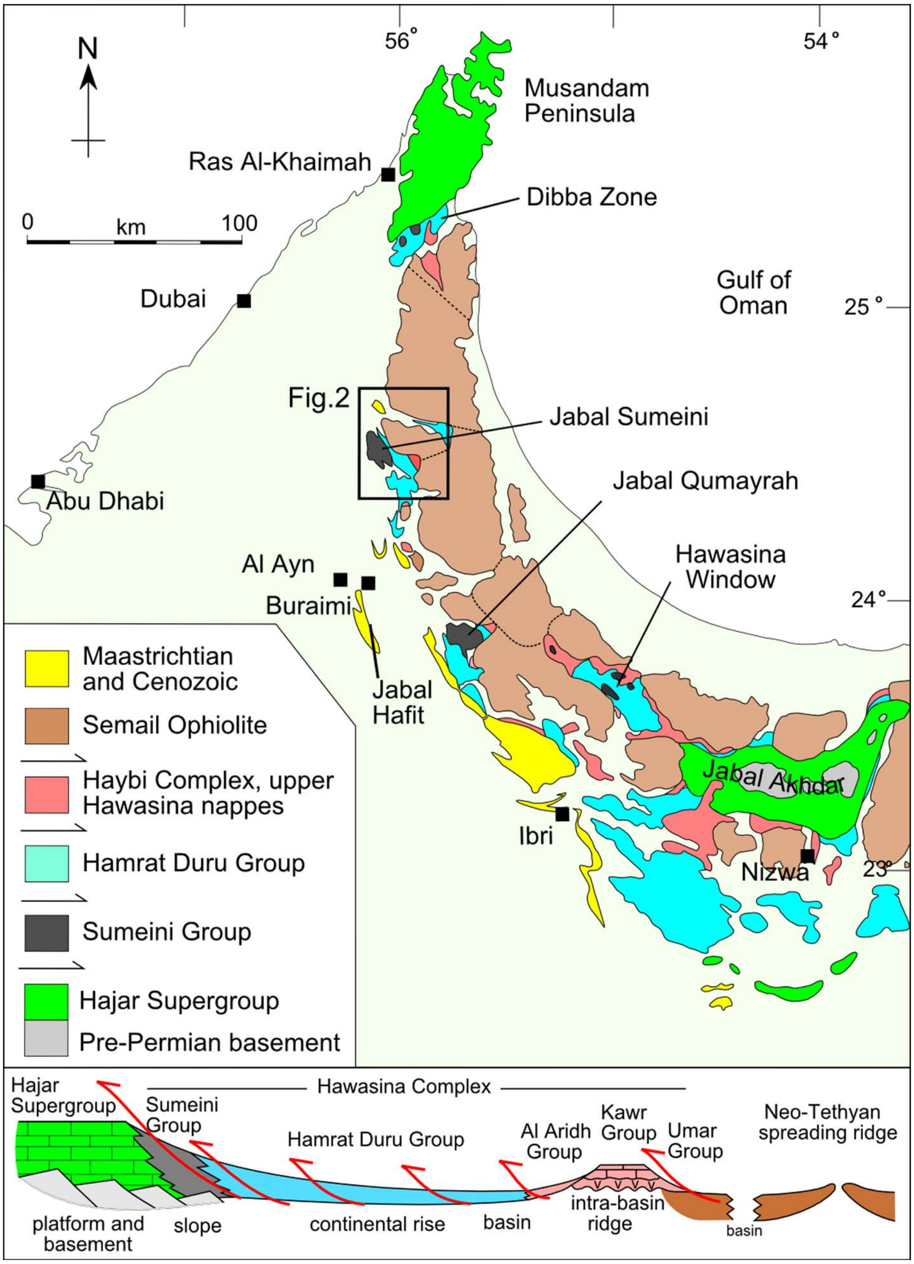

Fig. 1. Geological map of the Oman Mountains showing main tectonostratigraphic units and their schematic restored cross section within the Mesozoic Hawasina basin. The map is based on Glennie et al. (1974), Lippard et al. (1986), Bernoulli and Weissert (1987), Béchennec et al. (1990) and Cooper et al. (2014).

thrust-cored culminations that bring up to the surface structurally low stratigraphic units, the gypsiferous bodies in the Hawasina Window and Jabal Qumayrah are found in the centres of the culminations, whereas at Jabal Sumeini they crop out along its exposed western leading edge. Here, they are sandwiched between the units involved in the culmination, the Middle Permian to Cenomanian Sumeini Group, and Early to mid-Cenozoic sediments along the footwall of the structurally lowest exposed thrust, although seismic data suggest further thrust sheets are stacked at depth (Searle and Ali, 2009).

This paper investigates possible sources and mechanisms of emplacement of the gypsiferous rocks at Jabal Sumeini. While this area is within a patchwork of smaller evaporite basins of possible Ediacaran-Cambrian origin identified from studies of the regional gravity data (Ali et al., 2014b), there are also regional evaporitic units in the Permian and Mesozoic Neo-Tethyan Arabian plate succession, and Cenozoic evaporites linked to an interaction between eustatic changes and foredeep development along the western side of the Oman Mountains.

2. Geological development of the northern Oman Mountains and Jabal Sumeini

2.1. Geological overview of the northern Oman Mountains

The origin of the Oman Mountains lies in the Late Cretaceous foundering of the Neo-Tethyan passive margin of the northern Arabian plate from NE-directed subduction and obduction of a 500+ km long slab of oceanic crust and mantle, the Semail Ophiolite, and underlying thrust sheets. The ophiolite now structurally overlies subduction trench units of the Haybi Complex and imbricated thrust sheets of Middle to Late Permian and Mesozoic continental slope to deep-ocean sediments and lesser volcanics of the Hawasina Complex, (Fig. 1, Glennie et al., 1973, 1974; Searle and Malpas, 1980, 1982; Lippard et al., 1986; Béchennec et al., 1990; Cooper, 1990; Robertson and Searle, 1990; Rabu et al., 1993).

Emplacement of the Semail Ophiolite and Hawasina/Haybi units into the Aruma foredeep that developed ahead of the subduction zone was completed during the Santonian/Campanian (Warburton et al.,