Obduction and Collision Tectonics in Oman: Constraints from Structural and Thermal Analyses

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Abstract

In Oman, Permian-Mesozoic sediments belonging to the Arabian passive margin were overthrust by Hawasina deep-water sediments and Semail Ophiolite in late Cretaceous. Passive margin sequences and Hawasina units are now exposed in the Hawasina, Jabal Akhdar and Saih Hatat domes and at the Oman Mountains thrust front. Structural analyses were performed in the Jabal Akhdar Dome and in the Musandam area (where the Oman Mountains are characterized by a syntaxis), and samples from sub-ophiolite sediments were collected in the Hawasina, Saih Hatat and Jabal Akhdar domes as well as at the Jabal Salakh and the Musandam thrust front. The thermal evolution of sub-ophiolite sediments was investigated by clay-size-fraction X-ray diffraction (analyses for Musandam, Hawasina and Saih Hatat samples are in progress) and 1D thermal modeling allowed us to infer that sub-ophiolite units of central Oman were thrust over by a 4.5 km-thick pile of Ophiolite and Hawasina rocks during the Coniacian age, and exhumed in late Campanian. The sub-ophiolite rocks at the Jabal Salakh front suffered a burial of 3.35 km of clastic and allochthonous units. The Musandam thrusts are characterized by a first phase of dip slip and a second phase of dextral strike slip kinematics.

Keywords

Ophiolite • Obduction • Oman • Collision
Thermal maturity

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1 Introduction

The Semail Ophiolite constitutes an excellently exposed and complete ophiolite complex [1]. However, ophiolite thickness evaluation was achieved via measurements of stratigraphic sections, whose correlation is difficult due to internal deformation of the ophiolites and the lack of regional markers [2]. From the Hawasina and Jabal Akhdar tectonic windows, from a NNE-SSW fold of Hawasina sediments located SW of the Saih Hatat window and at the Jabal Salakh Range and Musandam fronts (Fig. 1), we collected samples of sub-ophiolite sedimentary rocks (Permian-Mesozoic sediments of Arabia passive margin, the Hawasina pelagic sediments) to constrain their thermal evolution via 1D thermal modeling and to reconstruct the thickness of the allochthonous units. In addition, structural analyses were carried out in the Jabal Akhdar Dome and in the Musandam area, where the Oman Mountains are characterized by a syntaxis (the thrust changes its orientation from NW-SE to NE-SW). Using these original multidisciplinary data, we constrained the Cretaceous-Cenozoic Oman Mountains evolution.

2 Methods

We performed X-ray diffraction (XRD) analyses to determine whole-rock composition and illite content in mixed layers I-S by using a Scintag X1 X-ray system (CuKα radiation) at 40 kV and 45 mA. Mixed layers of illite-smectite (I-S) and the transformation sequence diosmectite-random-ordered mixed layers (R0)-ordered mixed layers (R1 and R3)-illite-di-octahedral K-mica (muscovite) were used as indicators of the thermal evolution of sub-ophiolite sediments [1, 3]. These inorganic thermal indicators were used to constrain 1D thermal models, performed using Basin Mod® 1-D software.

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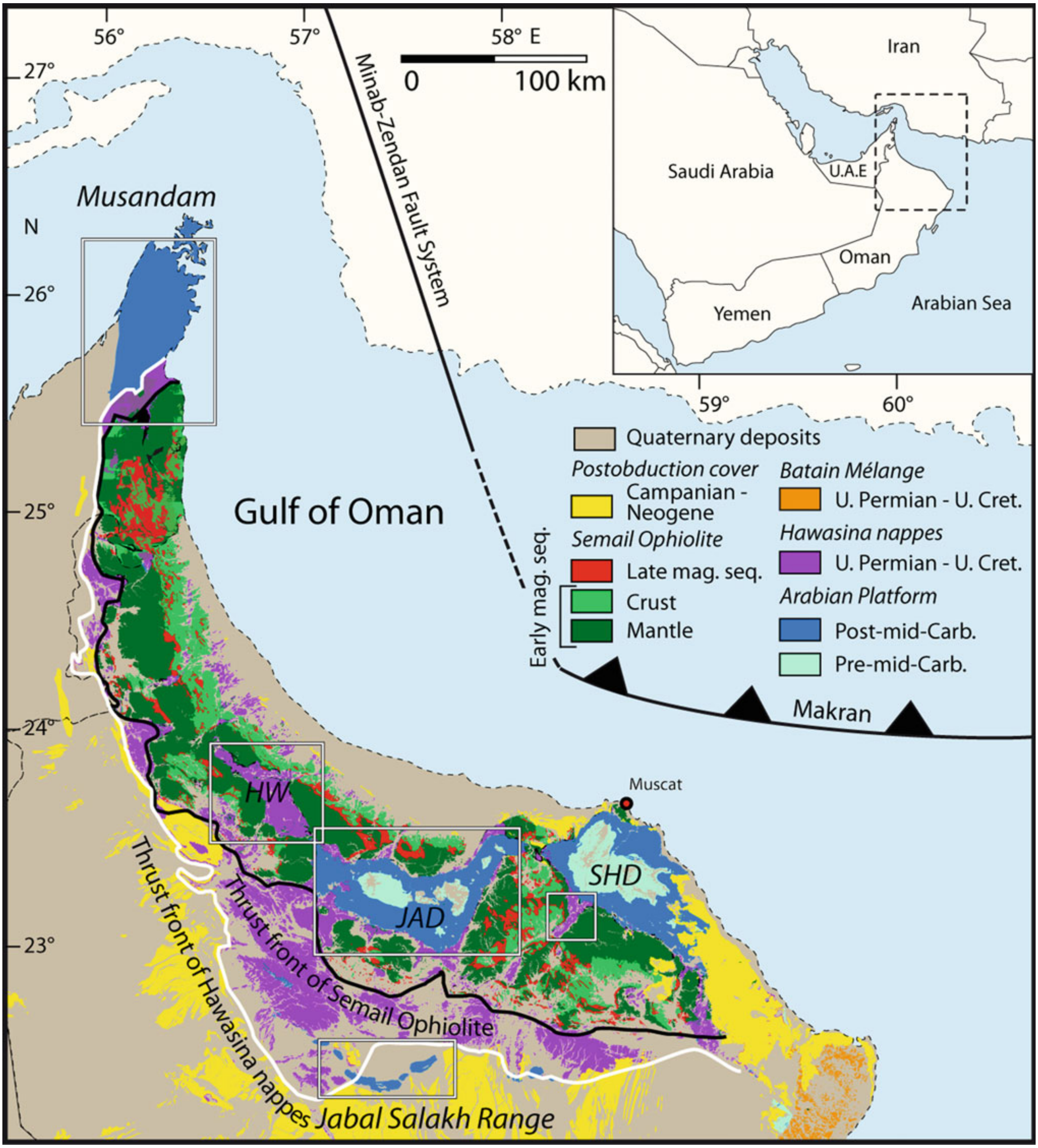

Fig. 1 Geological map of Oman, showing the study areas (black rectangles; modified and redrawn after [1]). Haybi thrust sheets, not described in the text, comprise the most distal (oceanward) Hawasina deposits. JAD: Jabal Akhdar Dome. SHD: Saih Hatat Dome. HW: Hawasina window

Structural analyses consisted in measuring kinematic indicators along faults and strain analyses on oolite-rich carbonates using the Flinn [4] and the Fry [5] methods.

3 Results

Thermal analyses for the Musandam, Hawasina and Saih Hatat samples are still in progress. The samples from the northern boundary of the Jabal Akhdar window show an illite content between 85 and 92%, long-range ordered mixed layer I-S of clay minerals and presence of pyrophyllite or/and paragonite, suggesting peak burial temperatures between 150 and 200 °C. In the southern flank of the window, peak paleotemperatures were 120–150 °C, indicating a decrease in the thickness of ophiolite/Hawasina toward the south. These results are consistent with plastic deformation (flattening and stretching in the x-z surface) and pressure solution of ooids along the northern boundary of the tectonic window. Along the southern flank, ooids show no ductile deformation, and brittle rheology is consistent with reduced overburden.

Mixed layers I-S show R1–R3 structures and ca. 80% illite content in the Jabal Salakh area. The Musandam thrusts, oriented NE-SW, i.e., perpendicular to the NW-SE thrusts of the Oman Mountains, are characterized by a first phase of dip-slip and a second phase of dextral strike-slip kinematics.

4 Conclusions

From combined analysis of thermal and structural data, we conclude that the sub-ophiolite sediments of central Oman were overthrust by a ∼4.5 km-thick pile of Ophiolite and Hawasina rocks during Coniacian and exhumed later in Campanian [2]. In the Jabal Salakh Range, sub-ophiolite rocks were buried under 1.35 km of clastic sediments and thrust by Hawasina sediments with a thickness of about 2 km. These results suggest a decrease in the thickness of the allochthonous units from NE to SW, in agreement with the strain analysis results and with their direction of emplacement. The peculiar orientation of the Musandam thrust and the change of kinematics (from dip- to strike-slip) suggest that they were possibly developed with a NW-SE trend (i.e., parallel to the remaining thrusts of the Oman Mountains), and were subsequently rotated to their present-day NE-SW strike during the development of the Musandam Syntaxis and then sheared again by dextral slip.

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